Bernardino Telesio and the Natural Sciences in the Renaissance

By

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[colophon]

Cover illustration: Bernardino Telesio, *De iride* (Venice 1590). Biblioteca Nazionale di Cosenza, Fondo Greco 476.

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Introduction

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Bernardino Telesio of Cosenza is one of the Renaissance thinkers who most strenuously defended the ideal of inductive science. He envisaged an inquiry of nature which was firmly anchored in empirical observation at a time in which this was far from common. A priori approaches, resting on standard *corpora* and a set of acknowledged authorities, prevailed in higher education and scholarly debates, despite the rise of a new practical culture in broad sectors of society. Telesio, who has been aptly called *uomo di un sol libro* (the man of one book),[1] continuously revised his major work *De rerum natura iuxta propria principia* throughout his life. This 'work of a life' underwent various changes, substantial amendments, and extensions, and appeared in three editions (Rome 1565, Naples 1570 and 1586). But its fundamental message was clear from the outset: Telesio urged natural philosophers to embrace an empirical, sensible investigation of the world. This method, contrasting with the 'bookish culture of the universities', would provide the basis for a renewal of a philosophy ideally addressing *nature itself* instead of abstract metaphysics. His contemporaries celebrated his attitude as a restorer of pre-Socratic naturalism, as is documented by the triangular exchanges between himself, his pupil the physician Antonio Persio of Matera, and the neo-Platonic philosopher Francesco Patrizi.[2] The 1570 edition began with a programmatic chapter (later adopted as the *prooemium* to the last edition) asserting that "the structure of the world and the nature of the bodies it entails should not be investigated through reason, as the ancients did, but they should be perceived by means of the senses and derived from the things themselves."[3] Telesio's refusal of abstract rationalism coupled with an anti-Aristotelian and anti-Scholastic drive resulted in opposing reactions: the indignation of university professors and ecclesiastical authorities on the one hand and the admiration of generations of *novatores* on the other. Actually, as many historians of science acknowledge today, scholasticism was less nefarious to the advance of natural knowledge than Telesio's battle might suggest; therefore, a confrontation between the influences on scientific thought stemming from the various Aristotelianisms and from his own views would be valuable to gain a more nuanced understanding of the intricacies of modern science. As for his specific contribution to

[1] Garin, "Postilla telesiana," 444.
[2] See Garin, "Nota telesiana" and Puliafito, "Introduzione."
[3] Telesio, *De rerum natura* (1570), f. 2*r*: "Cap. 1. Mundi constructionem corporumque in eo contentorum naturam non ratione, quod Antiquioribus factum est, inquirendam, sed sensu percipiendam et ab ipsis habendam esse rebus." Cf. Roberto Bondì, "Introduzione" to Telesio, *La natura* (2009), XVI.

the inquiry of natural phenomena, Telesio composed a series of *opuscula* dealing with aspects of the world, ranging from meteorology to the doctrine of the soul, as integral components of his all-encompassing natural philosophy.[4] Those *opuscula* were partly published as lone-standing essays (as was the case with *Ad Felicem Moimonam iris*, 'on the rainbow', in 1566), partly attached to Telesio's main work (*De mari*, *De his quae in aere fiunt,* and *De colorum generatione* accompanying the 1570 edition), and partly printed in a posthumous collection of *meteorologica* and *parva naturalia* edited by Antonio Persio under the title *Varii de naturalibus rebus libelli* (Various Booklets on Natural Subjects) (Venice, 1590).[5]

Materialist historians of science have suggested that the social roots of Telesio's sensualism are the same as those which determined the emergence of modern empirical science. In the context of a practically-oriented society, that of early European capitalism, the traditional divides between practitioners and learned élites were challenged and revised; in this context, a new class of scholars emerged, that of proto-scientists who combined the empirical knowledge of artist-engineers and the systematic reasoning of university scholars and learned humanists. The Renaissance produced many instances of this new type of intellectual: from Leonardo da Vinci to Girolamo Cardano, Niccolò Tartaglia, Guidobaldo Del Monte, Giovanni Battista Benedetti, Simon Stevin, and Galileo Galilei.[6] The Marxist historian Edgar Zilsel designated the 'magnetic philosopher' William Gilbert as the champion of modern experimentalism and stressed that he shared the critical attitude and radical anti-Aristotelianism of Italian philosophers such as Telesio, Tommaso Campanella, Giordano Bruno, and Patrizi. However, he remarked that their naturalism should be seen as the "older brother, not the father" of experimental science, since Gilbert's science *directly* stemmed from the practical knowledge of miners, foundrymen, navigators, and instrument-makers, and not from the philosophical discourses as in Telesio.[7] Interestingly enough, Zilsel describes Francis Bacon, together with Gilbert and Galileo, as another exemplar of the modern scientist, in spite of the fact that his contribution to science remained limited to its philosophical legitimation. Bacon's science-oriented philosophy rested on inductive logic, rejected metaphysics, and aimed at the advancement of knowledge for the benefit of mankind.[8] Regrettably, Zilsel failed to take into account Bacon's keen interest in Telesio's ideas, despite the ideal link between the latter's sensualism and the former's empiricism. Moreover, although the technological utopia of the *New Atlantis* (1627) is foreign to Telesio, his philosophical work played a comparable role in promoting scientific culture—if not that of the Royal Society, then undeniably that of the *Accademia dei Lincei* surrounding Galileian science.

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[4] Granada, "Introduzione" to Telesio, *Varii de naturalibus rebus libelli* [1590], XII.
[5] Cf. Telesio, *Ad Felicem Moimonam iris* [1566] and *Varii de naturalibus rebus libelli* [1590].
[6] Zilsel, "Sociological Roots of Science" [1942]. Among the many scholarly works drawing on Zilselian premises, see Renn, *Galileo in Context*. For a discussion of Zilsel's intellectual milieu cf. Long, *Artisan/Practitioners*, Chap. 1.
[7] Zilsel"Origins of William Gilbert's Scientific Method," 24.
[8] Zisel, "Sociological Roots of Science", 943–945.

In contrast to Bacon, and in addition to his advocacy of empiricism and his rejection of transcendence as a source of natural explanation, Telesio provided another significant contribution to the scientific culture of his age. Indeed, his work stands out as the first modern attempt at a new foundation for, and systematic elaboration of, natural philosophy. His most daring idea was that the entire architecture of natural philosophy could be erected on foundations different from those inherited from the past and that the principles of nature should be established anew, independently of academic traditions and scholarly authority. Such an uneasy but ambitious path was followed by his admirers, *in primis* Patrizi, Bruno, and Campanella. The philosophical assessment of the first principles of nature and of its 'laws' soon became an integral part of scientific debate, as can be seen in the philosophical systems of René Descartes, Pierre Gassendi, and other scholars of their century. In the age of mechanical philosophy, problems of physics, astronomy, and physiology were embedded within heated controversies over competing systems of nature. Rodolfo Garau, in the concluding chapter of this volume, argues that Telesio's idea of self-preservation represents the passage from a teleological to an autotelic understanding of natural processes, and also hints at some possible bearing of Telesio's doctrine of self-preservation on early modern inertial (or proto-inertial) natural philosophy, in particular on authors such as Descartes and Spinoza.

The Oxford erudite librarian Robert Burton, who witnessed the European reception of Telesio, mentioned him in a curious passage on "air rectified" in his multifaceted Renaissance encyclopaedia, *The Anatomy of Melancholy* (1621):

> Or, to omit all smaller controversies, as matters of less moment, and examine that main paradox of the Earth's motion, now so much in question: Aristarchus Samius, Pythagoras, maintained it of old, Democritus, and many of their scholars. Didacus Astunica, Anthony Foscarinus, a Carmelite, and some other commentators, will have Job to insinuate as much [...]. Howsoever, it is revived since by Copernicus, not as a truth, but a supposition, as he himself confesseth in the Preface to Pope Nicholas, but now maintained in good earnest by Calcagninus, Telesius, Kepler, Rothman, Gilbert, Digges, Galileo, Campanella, and especially by Lansbergius [...], by Origanus, and some others of his followers.[9]

Burton includes Telesio among the realist Copernicans and defenders of terrestrial motion. In the passage above he discusses heliocentric theory, referring to more or less legendary forerunners of Copernicus in antiquity in accordance with a widespread cliché. Burton then lists the supporters of the reconcilability of terrestrial motion and biblical exegesis, who are followed be the natural philosophers and astronomers. Burton brings together Celio Calcagnini, the humanistic author of a skeptical exercise defending terrestrial motion, *Quod coelum stet, Terra moveatur* (written around

[9] Burton, *Anatomy of Melancholy*, pt. 2, sec. 2, 52. On the British reception of Telesio, see Sandra Plastina, "Bernardino Telesio nell'Inghilterra del Seicento."

1518–1519 and first printed in 1544), with reputable mathematicians and astronomers, who either upheld heliocentrism or merely the axial rotation of the Earth, e.g. the German ephemerist David Origanus. Telesio's follower, Campanella, earned a place next to Galileo Galilei and Johannes Kepler owing to his *Apologia pro Galilaeo* (written around 1616 and first printed in 1622), a defence of Galileo which was actually meant to defend the philosophical freedom to discuss and argue in favor of Copernicus in the year of the Roman censure of the main theses of *De revolutionibus orbium coelestium*.[10] The reference to Telesio strikes the modern historian of Renaissance science in this context, because he is seldom mentioned among the protagonists of the 'Scientific Revolution' and never among those of the 'Copernican Revolution'.

Telesio did not adhere to the doctrine of terrestrial motion and did not take Copernicus into account in his monumental work. Astronomy remained peripheral to his intellectual endeavor. His most important study in this field is the booklet *De cometis et lacteo circulo* (*On Comets and the Milky Way*), written around 1580 and published posthumously by Persio (1590). Revising his earlier opinions, he rejected the sublunary location of all comets and the explanation of their light as inflammations, and embraced an 'optical theory' according to which they reflect solar rays. Although he did not cast doubt on the existence of material spheres in the heavens or the origin of comets from terrestrial exhalations, he derived evidence, on the basis of the observation of the comets of 1577 and 1572 (actually a supernova), that cometary bodies can trespass the boundaries of the sublunary world, and therefore that the heavenly spheres are permeable. As to the Milky Way, discussed in the same treatise, he regarded it as a heavenly phenomenon, a condensation of celestial matter in the sphere of the fixed stars.[11] Thus, in spite of the ambitious program of a universal reform of natural philosophy along an anti-Aristotelian line of thought, Telesio was not receptive to the most disruptive cosmology of his time. His astronomical views even presented a glaring contradiction such as the maintenance of Alpetragian celestial spheres despite their penetration by comets.[12] How then could Burton include Telesio among those scholars who read Copernicus in a *realist manner*, those who neglected the epistemological admonishment of the anonymous *Letter to the reader* of *De revolutionibus* to

[10] The mention of Democritus among the ancients is puzzling. In a cosmological discussion it would have been more apt to mention him as a supporter of the plurality of worlds and, perhaps, of space infinity, but not of terrestrial motion and heliocentrism. Actually, it was Bruno's intention to back Copernican astronomy with an atomistic physics reminiscent of ancient doctrines; the English reviver of Epicurean philosophy, Nicholas Hill, followed him in this aim. Since both names are remarkably absent, one is tempted to see Burton's Democritus as an allusion to these controversial atomists, who were suspected of impiety and persecuted by religious authorities. For a comprehensive discussion of the Renaissance cosmological context, see my *Copernicus in the Cultural Debates of the Renaissance*. As to Telesio's conception of space, it has been argued that his rejection of the Aristotelian theory of places and the idea that it is independent of and prior to bodies contributed to the affirmation of modern views of space as homogeneous and absolute. See Schuhmann, "Le concept de l'espace chez Telesio," 141–167.

[11] Cf. Granada, *Bernardino Telesio: Sobre los cometas*, especially the introduction. For a summary, see also my review.

[12] Lerner "La physique céleste de Telesio."

consider the heliocentric theory as a 'mere' hypothesis for the mathematical sake of simplicity?[13] Is this really a sign of confusion on Burton's part? Or is it rather an insinuation, perhaps a hint of the ongoing debates on the status of geometry and physics in the explanation of the heavens? In this context, the reference to Telesio might be a retrospective interpretation caused by the later discussion of his natural views within the astronomical controversies on the status of hypotheses.

The Copernican philosopher Bruno, for one, acknowledged Telesio in *De la causa principio e uno* (1584) as "giudiciosissimo Telesio consentino" (the very discerning Telesio of Cosenza)[14] and began his 'physical' defense of heliocentric astronomy, *La cena de le ceneri* (1584), with a reference to the Telesian bipolarity of nature, the opposition between solar warmth and terrestrial coldness: "Two [are] the contrary and active first principles, heat and cold. Two, the first parents of the things in nature, the Sun and the Earth."[15] Doctrines that fell even closer to Telesio's were propagated by Campanella—the forceful defender of Galileo's *libertas philosophandi* in the years of the *Affaire*, the revolutionary who drafted his utopic views in *Città del Sole* and the survivor of the jails of the Neapolitan and Roman Inquisitions who hazardously fled to France and attended the literary circles of Richelieu's Paris. Campanella dedicated the Paris edition of *De sensu rerum et magia* (1637) to the powerful cardinal. In this work he stressed the ontological basis of Telesian sensualism, i.e. a vitalistic conception of nature based on the assumption of universal sensitivity: "That which is in the effects has to be in the causes, therefore the elements and the whole have sensation."[16] Following Telesio's philosophy, Campanella posited two opposed principles of the world, *sole* (Sun) and *terra* (Earth), both endowed with sensitivity which they communicate to the plants and animals they generate.

One should mention medical studies as another area influenced by Telesio. This should include not only the well-known instance of Persio but also Telesio's possible influence within broader European circles, including those of radical Italian émigrés such as Agostino Doni of Cosenza. In chapter 10, Riccarda Suitner presents Doni's conceptions on the basis of his only extant work, *De natura hominis* (1581). She stresses both the divergences and the similarities between the doctrines of Doni and those of Telesio that have hitherto not been remarked upon by interpreters, based in particular on the 1565 and 1570 editions of *De rerum natura* which predate the publication of Doni's work.

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[13] Burton's synthesis of the astronomical debates of the time seems to confuse the *Letter to the reader* with Copernicus's dedication to the Pope, thereby ignoring Johannes Kepler's disclosure of the identity of the author of the epistle as the theologian Andreas Osiander in *Astronomia nova* (1609).

[14] Bruno, *Opere italiane*, *De la causa* III, 677.

[15] Ibid., *Cena* I, 443: "Doi [sono] contrari et attivi principii: il caldo et il freddo. Doi primi parenti de le cose naturali: il Sole e la Terra." Engl. transl. by Gosselin and Lerner (1995), 82.

[16] Campanella, *Del senso delle cose e della magia*, I 1: "Ciò ch'è negli effetti esser nelle cause, e però gli elementi e il mondo sentire." For a general introduction to Campanella's philosophy, see Ernst, *Tommaso Campanella*.

These examples show that the meaning of Telesio's work for the scientific debates of the Renaissance goes beyond the limits of mathematical astronomy and each science in particular. For his early readers, Telesio's main achievement was his daring project to establish a new basis for the sciences by composing a philosophical system capable of providing a viable alternative to Aristotelianism. He regarded nature as a process ruled by the eternal struggle between the two active principles of heavenly warmth and terrestrial coldness ruling over matter.[17] Telesio claimed that individual natural beings universally follow a principle of self-preservation, emphasizing a concept of *conatus* which in the seventeenth century bridged views on physical inertia and animal life.[18] Self-preservation also allowed him to connect the explanation of natural tendencies with human behavior. In the last edition of *De rerum natura*, Telesio expanded on the domain of ethics and politics. In his view, the virtues first emerge as a support and regulation of primary vital functions and then evolve into complex moral systems aimed at satisfying the needs of society. The further assumption that individual drives are unwittingly co-opted in the universal realization of the common good earned Telesio a place among modern theological-political thinkers.[19]

Telesio was not only concerned with the most general questions concerning the philosophy of nature; he was also devoted to the solution of particular scientific problems, especially in the *opuscula*. The nine booklets gathered by Persio in 1590 comprised four brief treatises on issues that pertained to meteorology according to the Aristotelian tradition. Specifically, they dealt with comets, the Milky Way, winds, earthquakes, the rainbow, and the sea, including the problem of the sea tides. The remaining five booklets dealt with problems of natural history that used to be labelled *parva naturalia*. One dealt with the unity of the soul against Galen, the others with the function of respiration, the nature of colors, taste, and sleep. These writings meant to offer naturalistic explanations of these natural phenomena in line with the doctrine expounded in *De rerum natura*, while at the same time testing the soundness of that doctrine. They should be understood in the context of Telesio's reception and criticism of the scholarly traditions represented by Aristotle and Galen. At the same time, they bear witness to Telesio's contribution to the scientific debates of his time.

In the opening chapter of this volume, Roberto Bondì offers an overview of the historical impact of Telesio's work, views, and methodology seen through the lenses of his immediate successors, particularly Bacon and Galileo. This overview is followed by several studies dedicated to Telesio's treatment of specific natural issues and their cultural context. Hiro Hirai (Chapter 3) explores issues linked to the generation of life in connection with Aristotelian and Hippocratic debates. Arianna Borrelli (Chapter 4) and Oreste Trabucco (Chapter 5) deal with meteorological questions, in particular

[17] The most accurate introduction is Bondì, *Introduzione a Telesio*.
[18] See *infra*, Garau, Chap. 12. For a comparative treatment of self-preservation in Telesio and early-modern philosophy, see Mulsow, *Frühneuzeitliche Selbsterhaltung*, 193–200.
[19] Giglioni, "Introduzione" to Telesio, *De rerum natura* [1586].

with the doctrines of heat, moving spirits, and winds. Borelli shows how Telesio's booklet *De iis quae in aere fiunt* (1570) not only revived Aristotelian explanations but also introduced the idea that spirits and vapours were capable of moving out of their own will, prompted by solar heat and by a desire to escape compression or dilatation. Borelli also places Telesio's meteorology in its larger historical context, specifically in relation to another very original treatise on weather and climate published a few decades later, Giovan Battista Della Porta's *De aeris transmutationibus* (1610). Trabucco's contribution testifies to the wide reception of Telesio's thought in sixteenth century natural philosophy by focusing on the *De causa ventorum peripatetica disceptatio* by Federico Bonaventura, which was published in 1592 in Urbino. This timely contribution to Renaissance studies redresses Bonaventura's so-far neglected criticism of some theses put forth by Telesio in his work *De iis quae in aere fiunt*.

My own case study (Chapter 6) is an investigation of Telesio's tidal theory in the context of the heated debates on this topic during the Renaissance. Telesio's theory is interesting because it rejects the possibility of an account of the sea-tides based on the moon, a view which the author connects to a long-standing epistemological commitment that favored causal explanations of natural phenomena over occult virtues. Further connections are made to prominent scholars of the time, such as Pico della Mirandola, Cesalpino, Sfondrati, Patrizi, and Galileo. Elio Nenci (Chapter 7) connects Telesio's views on the rainbow to the sixteenth-century reception of the Greek commentaries from Alexander of Aphrodisia and Olympiodorus on Aristotle's *Meteorology*. Nenci analyzes the representative exponents of these views within Renaissance Aristotelianism in order to identify the elements of continuity and discontinuity between the works of authors such as Alessandro Piccolomini, Ludovico Boccadiferro, Francesco Vimercati and Telesio's *De iride*.

Telesio's immanent perspective on nature and its implications for the doctrine of the soul worried religious authorities even more than his anti-Aristotelianism—which, in the climate of counter-reformist Italy, could be seen as a threat against Thomistic orthodoxy. His treatment of the soul as a *spiritus* of entirely natural origin in the first editions of *De rerum natura* aroused the attention of ecclesiastical censors. On April 28, 1570, Telesio wrote to the main ecclesiastical authority in Cosenza, Cardinal Flavio Orsini, to defend himself against rumors concerning the impiety of his conceptions. "In truth—he wrote—these two books deal with nothing but the first bodies and the principles, that is, warmth/coldness, humidity, and dryness. Very few things are asserted about the soul and only those that pertain to the matter of the principles and the sensitive and motive soul [...]."[20] The difficulty must have been serious and might explain the long time, from 1570 to 1586, that

[20] De Miranda, "Una lettera inedita di Telesio," 374: "Et veramente—he wrote—in questi doi libri non si tratta d'altro, che de li primi corpi, et de li principii cioè caldo freddo, humido, e secco. Dell'anima se ne dice pochissime cose. Et quelle sole, ch'appartengono alla materia delli principii, et all'anima sensitiva, et motiva [...]."

Telesio took to elaborate the last version of his work, in which the distinction between the *spiritus e semine eductus*, i.e. the natural soul, and the *anima a Deo immissa*, i.e. the soul of divine origin, was emphasized. Nevertheless, this caution (or clarification) was not sufficient to avoid censure. The Clementine *Index librorum prohibitorum* of 1596 suspended *De rerum natura* and some of the small natural treatises with the clause *donec expurgetur*. As no expurgation was ever approved, Telesio's 'dangerous' works remained prohibited to orthodox Catholics up to 1900, when they were taken off Leo XIII's *Index*. Miguel Ángel Granada (Chapter 2) offers an accurate reconstruction of Telesio's evolving views on "spiritus" and "soul," the sources he referred to, and the contextual reasons for his intellectual engagement with this problematic.

Three further essays contribute to the comprehension of the cultural environment in which Telesio lived and was received. Drawing on Antonio Persio's *De natura ignis et caloris,* which is preserved in the *Biblioteca Corsiniana* in Rome, Martin Mulsow discusses (in Chapter 8) a manuscript that documents a philosophical discussion on warmth and light that occurred in Naples in the 1570s. It offers a unique insight into Telesio's dialogical attitude and his confrontation not with Aristotle in the abstract but with the views of his contemporaries adhering to the Peripatetic school. Alessandro Ottaviani's contribution to this volume (Chapter 9) is a discussion of early documents connected with the censure of Telesio's ideas. He analyses a rare copy of the 1565 edition of Telesio's *De natura* preserved in the Biblioteca Corsiniana, Naples, which includes significant marginal annotations revealing of a time of intellectual censure linked to Counter-Reformation policies. Ottaviani's philological analysis allows him to posit that the author of the annotations was probably the Friar Angelo Baronio. This chapter is a valuable contribution to the reception of Telesio's philosophy and would also be relevant for readers interested in the history of the book and in inquisitorial procedures. Finally, Giulia Giannini (Chapter 11) considers the development of Renaissance academies through an analysis of Telesio's connection with them. She discusses the historical attribution of Telesio as the founder of the *Accademia cosentina* in his hometown, and considers whether an *Accademia Telesiana* existed or whether it is just a historiographic construction.

Telesio's troubles with censorship should be read against the background of a climate of increased religious tensions and attempts at control and censure.[21] In the same year in which Telesio wrote his self-exculpation to Cardinal Orsini (1570), the polymath Girolamo Cardano was tried by the Inquisition in Bologna for his heterodox views and astrology—sixteen years before this art was officially condemned by Sixtus V. He was subsequently forced to move to Rome, where he could be better controlled. The Neapolitan scientist Giambattista Della Porta was arrested in 1574 and condemned in Rome for necromancy. Many of his works, for instance the Italian version of *De*

[21] In order to relate these documents to the evolution of Telesio's thought (and his work itself), see Ottaviani's introductions to his editions of *De natura iuxta propria principia* of 1565 and the new version of 1570.

humana physiognomonia, could not be printed. Patrizi, who cherished Telesio's views and corresponded with him, was hired in Rome as a professor of Platonic philosophy and was immediately tried for the view on natural philosophy that he presented in *Nova de universis philosophia* (1591).[22] Besides the most severe theological allegations, he had to exonerate himself in 1592 from the suspicion of being a follower of Copernicus's system. As the Inquisition's documents read, "In *Pancosmia* [...] he [Patrizi] states 'that the motion of the Earth is by far in better agreement with reason than the motion of the heavens or the uppermost celestial bodies'. And he refers to Nicolaus Copernicus' sentence according to which the sidereal heaven is immobile, along with the stars, while the Earth moves."[23] Some of Patrizi's persecutors were later involved in Bruno's trial and condemnation to death, as well as in the Galileo *Affaire*. After a first imprisonment in 1592, Campanella was trialed in Padua and Rome (1594–1595) leading to his abjuration upon being vehemently suspected of heresy. His subsequent imprisonment in the Inquisition's jails of Naples and Rome lasted thirty years (1597–1634); he was spared the death penalty only because he resisted horrible tortures that deformed him permanently and he pretended to be insane.[24] Galileo and his Padua associate, the natural philosopher Cesare Cremonini, were investigated together by the Padua Inquisition (1604).[25] Telesio's works were publicly burned in front of the cathedral of Naples on St. Peter and Paul's day in 1610, together with other prohibited books. Hence it is no wonder that authors he inspired were reluctant to mention him directly, as was likely the case with Della Porta's views on heat and moving spirits in *De aeris transmutationibus* (Rome, 1610).[26] Campanella's Telesian work *De sensu rerum et magia* was confiscated by his oppressors, which forced him to rewrite it later by heart, in Italian, during his imprisonment, and then to translate it back into Latin.

Notwithstanding this climate of suspicion and censure, Telesio's ideas subtly entered the scientific culture of the seventeenth century. Bacon is perhaps the most evident instance of such influence, but other examples can be mentioned.[27] The English mathematician Henry Savile became acquainted with Telesio's philosophy during his continental *Bildungsreise*, discussed his ideas with Patrizi and Persio, and sent a copy of the 1570 edition of *De rerum natura* to the humanist Andreas Dudith-Sbardellati.[28] It has been shown that Telesian conceptions, particularly those relative to psychology, met with the keen interest of scholars linked to the Northumberand circle and were circulated among

[22] Cf. Rotondò, "Cultura umanistica e difficoltà di censori."
[23] Baldini and Spruit, *Catholic Church and Modern Science*, vol. I, 3, 51, doc. 1, 2216: "Lib. 17 Pancosmias fol. 103, pag. 1, col. 2.a ait quod Terram revolvi longe videtur esse rationi consonantius, quam Coelum, vel suprema astra moveri. Et refert sententiam Nicolai Copernici dicentis Coelum sydereum stare simul cum stellis, Terram vero moveri."
[24] Among others, see Del Col, *Inquisizione in Italia*, 552–565, and Black, *Italian Inquisition*, Chapter 7.
[25] Poppi, *Cremonini e Galileo inquisiti*.
[26] See *infra*, Borelli, Chapter 4.
[27] See *infra,* Bondi, Chapter 1.
[28] Iovine, "Henry Savile lettore di Bernardino Telesio."

English philosophers.[29] In Italy, the founder of the *Accademia dei Lincei*, Federico Cesi, was profoundly influenced by Telesio's conceptions.[30] The philosophy of *De rerum natura iuxta propria principia* was held in great esteem and critically assessed by the Lynceans. Persio discussed Telesio's conceptions on the nature of light with them in the years following Galileo's astounding telescopic discoveries.[31] Further documentation of the circulation of Telesian views in the scientific debates of the seventeenth century is found in Galileo's references to his work. In the last part of the *Dialogo sopra i massimi sistemi del mondo* (1632) Galileo deemed it necessary to introduce his own 'proof' of the Copernican theory, a mechanical explanation of the sea tides, by distancing himself not only from astrological interpretations of the phenomenon but also from Telesio's 'thermo-dynamic' account.[32] In spite of his disagreement on specific points, Galileo fiercely reacted in defense of Telesio's memory when it was discredited by his opponents. In the course of their polemics over cometary theory, the Jesuit Orazio Grassi accused Galileo of following Cardano's and Telesio's "sterile and unfortunate philosophy" (*sterilem et infelicem philosophiam*).[33] Galileo's reply in *Il Saggiatore* (1623) in defense of the two natural thinkers was firm: "Does he [Grassi] not notice how impiously he deprives them of all their reputation in order to hide a small blot on that of his master?"[34]

Telesio is emblematic of early-modern scientific culture in many ways. His attention to detail and experience and, at the same time, his aspiration to universality and all-comprehensiveness is typical of Renaissance science. His natural philosophy constituted a milestone in modern culture as a first systematic attempt at the foundation of the natural sciences, running counter to the Scholastic tradition. He is also representative of the ethical tensions affecting the natural debates of his age. His thought and its reception bear witness to the inseparability of the natural sciences and philosophy at a time when the natural disciplines underwent a process of rapid change, which led to an understanding of science and scientific methodology which is closer to our present understanding. This collection of essays is dedicated to him and the place of his thought at the crossroads of the natural sciences, philosophy, philology, and the life sciences. The contributors to the volume focus on the scientific-cultural context of this thinker as well as his scientific roots, and they deal with the question of his influence on the natural sciences of early modernity.

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[29] Cf. Spruit, "Telesio's Psychology."
[30] Galluzzi, *Libertà di filosofare*, 83–97.
[31] Gómez López, "Telesio y el debate sobre la naturaleza de la luz."
[32] See *infra*, Omodeo, Chapter 6.
[33] Grassi, "Libra astronomica ac philosophica" [1619], 118.
[34] Galilei, *Opere*, vol. VI, 236. On the reception of Telesio, also see Elisabetta Selmi, "'Formazione' e 'ricezione' del pensiero."

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6.

Telesio and the Renaissance Debates on Sea Tides

Pietro Daniel Omodeo

In the concluding sections of the naturalistic treatise *De mari* (On the Sea), Bernardino Telesio outlines an explanation of the tides, consistent with the general plan of his natural philosophy *iuxta propria principia*. In the same pages he distances himself from well-established explanations based on the remote action of the Sun and Moon. His criticism is part of a historical-scientific trend toward a physical explanation of the phenomenon that excludes common astrological accounts. In this chapter, I will provide the essentials for an understanding of Telesio's speculations within a process of empirical-rational emancipation that ideally links Pico's criticism of the belief in astral influences with the Copernican-mechanical explanation of the tides by Galileo in his *Dialogo sopra i massimi sistemi del mondo*.

1. Telesio's explanation of the tides

Telesio first deals with sea tides, the topic of the so-called *fluxus et refluxus maris*, in Chapter X of *De mari*, "Motum mari necessarium fuisse et a quibus intumescit moveturque" (The necessity of the motion of the sea, and by what causes it is moved and raised). According to Telesio, the general cause of the continuous motion of the sea is its simmering, produced by solar heat and the formation of vapors "which attempt to come out but are hindered in this attempt by the sea above; as a consequence they raise and swell it just like the spirit that fire generates in the water."[35] Hence the waves are analogous to the boiling of water in a pot.

> [...] and so one sees the alternating ebb and flow of the sea, mostly in equal time intervals of six hours. The reason is that during this time interval so many vapors are generated in the sea capable of raising and pushing it for that time. However, the rapidity of the sea seems marvellous in narrow and hollow places. In fact, in an open space nothing forces it [the sea water] to accelerate its motion if it is pushed by the sea behind. If it [the sea water] goes through narrow places it cannot pass all at once but only in part; as [this portion of the flowing sea water] hinders the flow of the [water] behind and hence is pushed and spurred, it accelerates its motion by necessity [...].[36]

[35] Telesio, *De mari* in *De iis que in aere fiunt et de terremotibus* (1990), 113: "li quali sforzandosi di uscire et essendo prohibiti di farlo dal mare sopraposto, a guisa di spirito generato nell'acqua dal foco, lo innalzono e lo fanno gonfiare."
[36] Ibid., 115: "[...] e così si vede, come per vicenda, il flusso e reflusso del mare, et il più delle volte in tempo eguale, e l'uno e l'altro in spatio di sei hore; e questo per che in quello spatio di tempo si generono nel mare tanti vappori, che per quel tempo lo possono inalzare e spignere; ma ne' luoghi stretti e ne' cavati apparisce maravigliosa la celerità del mare, per che scorrendo egli per loco aperto e non essendo dal mare anteriore sospinto, non ha cosa che lo stimoli a concitare il

The tides are thus a marine simmering, which must be related to the flow of currents in the straits. Telesio advances the idea of a circular motion of the waters toward the west observed not only in the Mediterranean but also in regard to ships crossing the oceans. The Spanish navigators employ 24 days to reach the New World but a full three months to return, "as they are hindered by the opposite waters, flowing in the opposite direction."[37] Similarly, the Portuguese navigators are hindered by the flow of water in their journeys to the East Indies beyond the Cape of Good Hope but are aided during the return voyage for the same reason.

In Chapters XI and XII of *De mari*, Telesio discusses and refutes the theories of those who believe that the phenomenon of the tides results from the remote action of the sun or moon. Some conceive such action as an influence (*influxus quidam a Luna in mare missus*), others as a magnetic action (*quomodo ferrum ad magnetem*). The main difficulty of these explanations is in assuming the possibility of long-distance actions without intermediate causes, which we could call 'arcane' or 'occult'. Telesio puts the reader on guard against those who assume that there is an "incorporeal faculty emitted by the moon" (*incorporea facultas a Luna emissa*).

> One should not listen to them just as [one should not listen to] those who assert that the Moon emanates an incorporeal faculty (something that the human intellect finds impossible to understand) which raises and moves the whole sea with such great and many motions without moving any other being, even if there is earth between it and the Moon.[38]

In Chapter XIII, Telesio provides an explanation of the tides, particularly of the variability of their amplitude at different locations. The variations depend on the different water depths and meteorological, climatic, and seasonal variations, which result in in unequal amounts of solar heat. The moon in opposition would produce a greater simmering of the seas. In other words, Telesio does not deny that the sun and moon should be taken into account in tidal theory, but he 'rationalizes' their action in terms of a heating by the rays of the sun and their propagation by the moon's reflection of sunlight. The basic periodicity of six hours is also not questioned and it is not linked to the diurnal cycle and the position of the moon. Rather, it is considered a natural cycle of the waters, in which the flow is followed by an ebb aimed at restoring the original condition.

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moto; ma passando per lochi stretti non può correre tutto insieme, ma solamente una piccola parte, e quel che rimane dando impedimento al corso di quello che li vien dreto, e per ciò essendo sospinto e stimolato, è necessario che egli acceleri il moto [...]."

[37] Ibid., 117: "repugnando loro le acque contrarie, in contraria parte correnti."

[38] Ibid., 123: "[Costoro] non dovrebbero essere ascoltati come quelli che vogliono che la Luna emetta una facoltà incorporea (cosa che non è possibile comprendere con l'intelletto umano) la quale senza muovere le altre acque ed alcun altro ente [...], innalzerebbe e muoverebbe con così grandi e numerosi moti tutto il mare, persino quello al quale la terra stessa s'inframmezza tra esso e la Luna."

It seems that Telesio was not completely satisfied with his own theory, so much so that he deleted the last three chapters of *De mari* from the Neapolitan edition of the naturalistic *opuscula* of 1570. These sections only appeared in the posthumous Venetian edition edited by his pupil Antonio Persio in 1590.[39]

Let us summarize the main points of Telesio's tidal theory. First the phenomenon is inserted in the more general topic of the motion of the waters. This fits within the Aristotelian-scholastic discussion of the natural motions of the elements, especially connected with the reception and comment of *De coelo* and *Meteorologica*. Instead of a 'natural motion' (*motus naturalis*), Telesio considers the motions of the waters to be processes of boiling dependent on the action of the Sun. He also believes that the overall motion of the seas is a circular flow toward the west, a hypothesis supported by the ocean voyages of the Spanish and Portuguese seamen. The tides have a periodicity of six hours although their amplitude varies according to a number of local climatic, meteorological, and geographical conditions. For example, the presence of straits or the conformation of the coasts either facilitates or hinders the marine flows. Hence Telesio's explanation is in contrast to the theories of those who assume that the origin of the tides is a remote action without intermediate causes. In this sense, Telesio's theoretical attempt is part of a process of 'mechanization' or at least of anti-astrological physical explanations since it excludes factors operating at a distance. All of these aspects must be considered in detail with reference to the wide-ranging Renaissance debates on sea tides and maritime flows.

2. The tides as an astrological subject: Albumasar's legacy

It should be stressed that in the late Middle Ages and Renaissance the subject of the tides had a clear astrological connotation. This explains Telesio's concern about explanations of sea tides assuming a distant action of the Moon reminiscent of astrological influences. Indeed a reference source on this topic was one of the most widespread texts devoted to astrology, Albumasar's *Introductorium in astronomiam* (Introduction to Astronomy): "One can say that it is from this book—wrote Pierre Duhem—that all the [scholars of the] Latin Middle Ages learned the laws of the ebb and flow of the sea."[40] For the famous ninth-century Persian astrologer, the phenomenon of the tides is clear and incontrovertible proof of the influence of the stars on terrestrial events. The action of the moon on the waters is second in magnitude and visibility only to seasonal effects determined by the sun, by its annual journey along the zodiac and by its variations in declination. In other words, in the

[39] Cf. De Franco, "Nota introduttiva."
[40] Duhem, *Le Système du Monde*, vol. 2, 369: "C'est dans ce livre, peut-on dire que tout le Moyen Age latin a appris les lois du flux et du reflux de la mer. La doctrine d'Albumasar mérite donc que nous y arrêtions avec quelque complaisance."

Introductorium the consideration of the tides is functional to an astrological interpretation of sublunar events.[41]

Albumasar carefully examines the subject in the third book of the treatise from the fourth chapter to the eighth. The lunar influence on the seas is introduced as a special relationship of the celestial body of the moon with the watery element. The sun has a particular influence on two of the four natural elements of Aristotelian tradition: fire and air; the moon affects the remaining two: earth and water. The explanation of the tides is based on a triad of causes: the conformation of the locality (depth, length, and breadth), the particular condition (*habitudo*) of the water (agitated or not because it is brought by rivers or is near sources, the density, salinity, and mixture of vapors) and lunar motion.[42]

The moon's influence is the basis of the fundamental regularity of the tides, whose variability is linked to several factors, not least the latitude of the seas subject to the lunar action. The moon attracts the waters through a particular force, which acts by affinity or sympathy. In Latin this is called a *cognata virtus* (force of affinity), a type of astrological consonance acting without intermediate causes. The docility of the waters, induced to follow the lunar motion, is indicated as a "spontaneous inclination to be pulled" (*spontaneitas ad tractionem*). The rise of the waters, as Albumasar explains, is primary and depends directly on this astrological traction. The ebb is instead secondary, being a movement only aimed at restoring the original condition prior to the external action of the moon.[43] Moreover, the former tendency is a kind of boiling and thus is warmer than the latter: "The flow [*accessus*] is a warming of the water and the ebb [*recessus*] a cooling down. In fact, during the flow it boils from the profoundest abyss; during the ebb the [water that] overflowed becomes colder."[44] Note that this idea is also used by Telesio in his explanation of the waves but in a completely different natural-philosophical framework. One could say that he does not reject the observation and description of the phenomenon but seeks a physical cause different than the astrological one.

In the seventh chapter of the third book of the *Introductorium*, Albumasar also addresses the opinions of critics of the moon's remote action as the cause of the tides. In other words, he deals with those who deny one of his main arguments in favor of the astral influence and of astrology. According

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[41] Albumasar, *Introductorium in astronomiam*, a3r-v.

[42] Ibid., c1v: "Dicimus igitur quod nunquam huiusmodi accessus et recessus nisi trium rerum conventu gignitur, loci videlicet natura, aquarum habitudinem [sic!], [et] motu <Lunae>. [1.] Loci natura est ut aquarum locus profundus, longus et latus vix temporis impendio transfretandis montuosus asper et durus quale vi quolibet motu acriter repercusse multe unde tumidos fluctus concipiant. [2.] Aquarum habitudo est tantas in huiusmodi loco longo ex temperie aquas esse confusas ut nec in fluxu fluminum nec ex collatione fontium augerive minui sentiatur. Que quanto ipse condensate salebre calefacte densos vapores agitent qui terre vaporibus permixti agitandis undis aspirent. [3.] Motus autem <Lunae> desuper orientis atque occidentis sepius repetitus cognata virtute eiusmodi aquas trahit: quem tractum sponte sequens quousque illa accedit: accedunt usque adeo quoad diffusius eferventes loco suo minus contempte extremis inundent littoribus."

[43] Ibid., c3v.

[44] Ibid., c2r: "Est autem accessus quidem aque calidior et recessus frigidior. In accessu namque ex imis abyssis ebulliunt in recessu forinsecus expanse infrigidant."

to them, the tides are caused by tendencies intrinsic to the waves, and thus the tides are reduced to a wave phenomenon. Albumasar's refutation is based on several considerations. Firstly, if the tides were determined by the *nature* of the waters, i.e. by an internal tendency, there would not be variations in timing and in amplitude nor a parallelism with respect to the lunar motion. Secondly, it is not credible that the waters of basins overflow from their usual place by means of spontaneous motion. Moreover, waters have an inherent tendency to move downward, as Albumasar argues, following Aristotle's physics. Hence it is difficult to comprehend by what natural tendency they can be induced to rise. Albumasar concludes that the cause must be extrinsic and the only such ascertainable cause is the moon.

3. Pico's criticism of the lunar explanation of the tides

The centrality of the lunar theory of the tides, as well as the breadth of discussion in Albumasar's *Introductorium*, meant that the critics of astrology could not ignore the topic. Before Telesio's refusal of astrological tides, Giovanni Pico della Mirandola dedicated several pages to this problem in his famous argument against astrology, *Disputationes adversus astrologiam divinatricem* (Disputations against Divinatory Astrology, published posthumously in 1496). Chapter xv of the third book is entitled "The Sea Tides Can Be Explained through a Cause Different than the Moon; Even if This Were the Explanation, It Would Not Support Astrology" (*Aestus maris in aliam causam quam in Lunam referri posse, in quam et si referatur nihil inde iuvari astrologiam*). Pico observes that the question is complex because *everyone* is of the opinion (*cum omnibus videatur*) that the moon is the origin of the phenomenon. It is worthwhile considering his critique since it constituted an important point of reference for subsequent anti-astrological explanations of marine motions.

Pico begins with a series of considerations taken from Adelard of Bath who explained the tides as a motion caused by the tendency of waters to reunite when they are separated by land, according to the principle that "the elements, as parts of a whole, have a natural tendency to restore the [original] integrity" (*naturali propensione feruntur elementi cuiusque partes ad suam integritatem*).[45] This tendency did not coincide with the natural motion of the element but rather a law regulating the behavior of the parts of a whole.[46] As one reads in Pico, the phenomenon can be explained without recourse to celestial causes simply by considering the tides as a process of boiling followed by an expansion of the element (i.e. *accessus*) and then by cooling and contraction (*recessus*):

[45] Pico della Mirandola, *Disputationes adversus astrologiam divinatricem* III 15 (2005), 488.
[46] Ibid.: "Hunc accedendi recedendique motum naturalem esse aquae non quatenus aqua est, sed quatenus partes habet elementi principalis, objectu molis terrenae diremptas et separatas."

> Therefore, some will consider the following cause of the sea tides as clear enough and sufficient: that vapors and [...] winds rise from the earth and water so that wind and turmoil is to be found in the water and, in particular, that this motion and impulse, and the mixing of vapors, warms [the water]. As a consequence, it needs a wider space to expand. By contrast, if that force extinguishes because the vapors are dissolved, [the waters] go down and flatten. They contract in narrow places and descend from the places they occupied.[47]

Such thermal theory anticipates the more articulated one by Telesio. Pico stresses that this explanation is based on nothing other than the *nature* of the sea. He concludes by referring to natural reason and experience: "If [this explanation] is in agreement with natural reason and if it is in agreement with experience, why should we regard them as less likely? Moreover, why should we add the lunar motion to these causes [...]?"[48]

Pico then refutes the "Saracens," supporters of a celestial theory of the tides, which violates rational-empirical evidence. He names two of them: Albumasar (*Aboasar*) and Alpetragius. The former is mentioned in regard to lunar causation. The latter is attributed with a general theory of celestial causation of the sublunar elements.[49]

Alpetragius (al-Bitruji, XI century), a contemporary and fellow countryman of Averroes (Ibn Rushd), dealt with the motion of the elements (*motus elementorum*) in the fourth chapter of his physical-astronomical work *De motibus celorum* (On Celestial Motions), which strongly influenced Girolamo Fracastoro and other homocentric astronomers of the Italian Renaissance.[50] As one reads in Alpetragius' work, all of the sublunar elements are affected by the circular motion of the stars but in a progressively reduced manner the farther they are from the celestial sphere. Fire is moved at almost the same velocity as the celestial bodies, as evidenced by comets or similar 'meteorological' phenomena (*quod apparet de similibus stellarum que videntur in quibusdam horis incensis in aere*). Air is slower; whereas the motion communicated by the heavens to water is that of the tides, attributed by many (mistakenly) to the moon:

> And the motion of the water is less rapid than the air. For this reason it is believed that its motion follows that of the moon, in consideration of the closeness of their motions (of the moon and the sea); and hence, it was also believed that it [the sea] follows it [the moon] and is attracted by the latter.[51]

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[47] Ibid., 488–489: "Poterit autem cuipiam hinc apparere satis aperta et sufficientis causa, marinae reciprocationis, siquidem de tali terra et aqua, vapores [...] ventique suscitantur, unde in aqua sit ventus, tumultus, praesertim quod ex motu impulsuque isto, et vaporum admixtione, calescit, quare locum quaerit ampliorem quo se diffundat. [...]. Rursus ubi vis illa dissolutis vaporibus conflamescit, subsidunt atque sternuntur, et in angustiis se contrahentes, ab occupatis locis abscedunt."

[48] Ibid., 489: "Quae si rationi consonant naturali, si consonant experimentis, cur parum probabilia iudicari debent? Aut cur necessarium praeter has causas addere Lunae motum [...]?"

[49] Ibid.: "Alpetragius attulit huius motus coelestem causam, nec a Luna, verum a diurno motu quo movent omnia. Sed inferiora minus. Ignis enim sphaera rotatur in orbem. Inordinatus motus in aere fit, quae in aqua definit in accessum atque recessum."

[50] Al-Bitruji [Alpetragius], *De motibus celorum*, 80–82. Cf. Di Bono, *Le sfere omocentriche di Giovan Battista Amico*.

[51] Ibid., 81: "Et motus aque est minus velox motu aeris; et propter hoc creditur quod ipse sequitur in motu suo motum Lune propter propinquitatem suorum motuum (Lunae scilicet et maris); et propter hoc credebatur quod ipsum sequebatur ipsam et incurtat ab ipsa."

Alpetragius' explanation of the tides is based on the action of the heavens, the *ponderositas* (weight) of the waters and their *multitudo* (which probably means volume). The movement of the tides would go unnoticed if it could not be seen on the seashores (*ubi non invenitur nisi una ripa propter sui magnitudinem et profunditatem*). The east to west flow of the waters, of celestial origin, strikes the coast. The result is an oscillating motion of the tides due to a triple impulse: the westward tendency (communicated by the stars), a resistance in the opposite direction (because of the "weight") and a downward resistance, called *multitudo* or quantity (which is the natural tendency of waters):

> The motion of the water from the east is a motion that imitates that [motion] which is above it. Its motion backwards is due to its weight [*ponderositas*] and its downward thrust is due to its quantity [*multitudo*].[52]

"But it is evident—Alpetragius concludes—that the earth rests in its entirety"[53] even though its parts can be subjected to local movements. In short, the work of this medieval scholar provides an account of the phenomenon of the tides within an astronomical-cosmological context that comes closer to early-modern mechanic accounts (which I will soon discuss) than to the thermal theories of Pico and Telesio. Alpetragius explains the tides in causal terms and without recourse to 'occult' or hidden forces (*virtutes occultae*). His considerations concern the nature of the waters and the universal circulation of the cosmos toward the west rather than the distant action of the moon.

Let us return to Pico's *Disputationes*. After maintaining the plausibility of a non-astral explanation of the tides, Pico admits—for the sake of argument—but does not concede that the moon might be responsible for them. He stresses, however, that the only possible actions of the heavenly bodies on terrestrial ones occur through motion or light and not through occult influences (*occultis influxibus*). "Whichever of these traditions one accepts, it is clear that we are not forced to ascribe any new power to the moon producing the motion of the sea, except for motion and light."[54] The concomitance of lunar motion and tides can be considered a sort of parallelism rather than a causal relationship: "if we allot that effect to the moon, we will refer such motion to a tacit natural harmony according to which motion is imitated when the occasion is given, as it [the sea] rises when the moon rises and descends when the latter sets."[55] However, despite whatever concession might be made to the astrologers as far as natural philosophy is concerned, Pico does not compromise regarding the ethical implications. It is not permissible to infer from the observation of celestial causes that human actions, be they small

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[52] Ibid.: "Tunc motus aque qui est a parte orientis est motus quo consequitur ipsum quod est superius ad ipsum, et sua reversio est propter eius ponderositatem, et eius declinatio deorsum propter sui multitudinem."
[53] Ibid.: "Sed terra apparet quod quiescit simpliciter in toto."
[54] Pico, *Opera*, 492: "Verum quaecunque potius recipiatur harum traditionum, patet nihil nos cogi novam comminisci potestatem in Luna, praeter motum et lucem, quare mare commoveat [...]."
[55] Ibid., 491: "[...] nos si pertinet ad Lunam talis effectus, ad eius id motum referamus quem tacito naturae consensu, occasioni motus imitatur, quare ascendit cum ascendente [Luna], descendit cum descendente."

or large (*et parva et maxima*), individual or collective, are guided and sustained (*duci et regi*) by stars and planets.[56]

To summarize, Albumasar provided the Latin Middle Ages and the Renaissance with an astrological interpretation of the tides based on the remote action of the moon on the waters of our planet. This influence was an unspecified force of affinity (*virtus cognationis*). Such an explanation approaches the modern post-Newtonian theory based on the law of universal gravitation in different ways, but was also accused of being an undue recourse to occult influences (*occulti influxus*). Pico's refutation, included in the fiercest anti-astrological indictment of the fifteenth century, appears to be particularly important. It opened two paths to those who shared his suspicion of an astrology-based theory applied to the lunar explanation of the tides: they could either reject the lunar influence *in toto*, and thus venture into a search for a new explanation, or accept some account in which the moon was granted nothing more than an action through movement and light. Pico provided an intrinsic explanation of the phenomenon (which he saw as rational and empirical) relating the *aestus maris* to a kind of alternating expansion of the waters through boiling and contraction of them through cooling. Telesio's account followed in his footsteps but did not constitute the only alternative to astrology.

4. Giordano Bruno's vitalistic approach to the tides

The denial of the lunar causation of the tides—which was closely related to the criticism of astrology—called for a revision of the explanation of the phenomenon during the sixteenth and seventeenth centuries. Giordano Bruno, who was among the authors who sought an alternative, offered a vitalistic account in the fifth dialogue of *La cena de le Ceneri* (The Ash Wednesday Supper, 1584). He denied that the tides were caused by the distant action of the moon, and accepted that there is a correspondence between the positions of the moon and the movements of the waves, but thought that it depends on a kind of harmony of nature by which the laws regulating one process can correspond to those governing a parallel one without there being a causal link. This means that the positions of the moon can be considered *signs* of the rise and fall of the sea level without being considered a *cause*.

The starting point for Bruno is a type of astrobiology according to which the planets' bodies "possess the principle of intrinsic motion [through] their own natures, their own souls, their own intelligence."[57] Since the principle of motion is inherent to the moving object, there is no need to invoke some "tractive or impulsive force or something similar, which cannot be done without the

[56] Ibid., 490.
[57] Bruno, *The Ash Wednesday Supper* (1995), 206. Cf. *La cena de le ceneri*, in *Opere italiane*, 427–589, 547-548: "Questi corridori hanno il principio di moti intrinseco la propria natura, la propria anima, la propria intelligenza."

contact of at least two bodies."[58] Bruno maintains that each body that moves without *appreciable contact*, as if affected by another *driving or attracting* body, should be explained on the basis of a spontaneous internal principle (*appulso*). Everything that moves with respect to something else without contact and as if propelled by some deprivation or desire does so by spontaneous motion: it is the iron object that moves the magnet, not the latter that forces the movement; similarly the straw moves spontaneously toward the amber, the feather toward the jet, the sunflower toward the sun. The motion of the tides must also be discussed and explained in this perspective:

> Upon the consideration that nothing moves in space on account of an extrinsic principle, without a contact more forceful than the resistance of the medium, depends the further consideration that it is solemn foolishness and an impossible thing to persuade an orderly mind that the moon moves the waters of the sea [causing tides], […] since for all these things it is properly a sign and not a cause. It is a sign and indication, I say, because the observation of these things [together] with certain dispositions of the moon […] proceeds from the order and correspondence of things, and from the laws of one mutation which are in conformity and correspondence with the laws of another.[59]

The idea that motion is caused from within the moving body infringed against an established Aristotelian principle that "nothing moves by itself." By contrast, Bruno sought an inner cause of motion, which is well in accordance with his vitalistic philosophy of nature. Living beings act following their inner tendencies. A similar idea was proposed by Francesco Patrizi, who wrote that the motion of the seas originated in an intrinsic impulse, and that this impulse was similar to the one that moves the animal-like planets in ethereal space.

Bruno concludes his remarks on the tides with a criticism of *so many strange philosophies* that confuse *signs* and *causes*. The reference is to astrology, which mistakenly believes that the movements of the stars are causes and not *signs* of earthly affairs.

Similarly, geometricians often confuse *signs* and *natural causes*, for example when they state that the perpendicular rays of the sun cause more heat, when the cause of the heat can only be material, i.e. the greater or lesser persistence of the sun on the earth. "It is one thing to play with geometry and another to verify with nature. It is not lines and angles which make the heat of fire more or less, but distance and nearness, long and short duration." [60] Such preference accorded to natural causation over

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[58] Ibid., 206. Cf. Bruno, *La cena*, 548: "virtù trattiva, o impulsiva, et altre simili, che non si fanno senza contatto di dui corpi almeno."

[59] Ibid., 207. Cf. Bruno, *La cena*, 548-549: "Da questo considerar che nulla cosa si muove localmente da principio estrinseco senza contatto più vigoroso della resistenza del mobile, depende il considerare quanto sii solenne goffaria, e cosa impossibile a persuadere ad un regolato sentimento, che la luna muove l'acqui del mare, caggionando il flusso in quello [...]: atteso che quella [...] è propriamente segno, e non causa [...], perché il vedere queste cose con certe disposizioni della luna [...] procede da l'ordine e corispondenza delle cose, e le leggi di una mutazione, che son conformi o corrispondenti alle leggi de l'altra."

[60] Ibid., 208. Cf. Bruno, *La cena*, 549-550: "Altro è giocare con la geometria, altro è verificare con la natura. Non son le linee e gli angoli che fanno scaldar più o meno il fuoco; ma le vicine e distanti situazioni, lunghe e brieve dimore."

mathematical modelling makes Bruno's path to science closer to Telesio than to the physico-mathematical path that, in the Italian Renaissance, would culminate in Galileo's work.

5. Mechanical explanations of the tides: Galileo's teacher Cesalpino

In spite of the evident methodological differences, Giovanni Aquilecchia highlighted a possible link between Bruno's rejection of the remote action of the moon on the tides and the much better known and articulated discourse on the tides by Galileo in the concluding part of *Dialogo sopra i massimi sistemi del mondo*. It should be stressed that Telesio also contributed to the calling into question of the lunar action. More specifically, for Galileo the tides are not ascribable to an action of the moon but constitute tangible proof of the motion of the earth.[61] His explanation, on closer inspection, is rather mechanical and not based on a vitalistic and teleological concept of the inherent impulse of bodies to motion or to some tendency to self-preservation. If there is a common foundation of the criticism of the lunar theory in Telesio, Bruno, and Galileo, it is the criticism of astrology and the distant influence of the stars, not the explanations they provided, which are rather different indeed.

The fundamental thesis of "Day Four" of the *Dialogue Concerning the Two Chief World Systems: Ptolemaic and Copernican* (1632), a section entirely dedicated to the tides, is "that if the terrestrial globe were immovable, the ebb and flow of the oceans could not occur naturally; and that when we confer upon the globe the movements just assigned to it [by Copernicus], the seas are necessarily subjected to an ebb and flow agreeing in all respects with what is to be observed in them."[62] Galileo sought in the tides an incontrovertible proof of the earth's motion. Renouncing both the action of the moon and proto-gravitational considerations, he explained the phenomenon in what one can call inertial terms. The rise and fall of the waters depend on the combined action of daily axial rotation and annual revolution.[63]

Galileo claimed the absolute originality of his explanation of the tides. Certainly he took a step forward with respect to his predecessors in combining tidal theory, Copernican hypotheses, and mathematical physics. Nevertheless, in light of the broad Renaissance discussion on terrestrial motion (*motus terrae*), elemental motion (*motus elementorum*) and tides, the words of the Copernican Salviati in Galileo's *Dialogue* sound ironic: "[...] what I am about to say, I propose merely as a key to open portals to a road never before trodden by anyone [...]." [64] Indeed, the portal (*la porta*) and the

[61] Aquilecchia, "I *Massimi Sistemi* di Galileo e *La Cena* di Bruno."
[62] Galilei, *Dialogue Concerning the Two Chief World Systems*, 417. Cf. Galilei, *Le opere,* vol. 7, 443: "che quando il globo terrestre sia immobile, non si possa naturalmente fare il flusso e reflusso del mare; e che quando al medesimo globo si conferiscano i movimenti già assegnatili [da Copernico], è necessario che il mare soggiaccia al flusso e reflusso."
[63] For a recent examination of Galileo's tidal theory, see Clutton-Brock and Topper, "The Plausibility of Galileo's Tidal Theory."
[64] Galilei, *Dialogue*, 418. Cf. Galilei, *Le opere*, vol. 7, 444: "E quello che io sono per dire, lo propongo solamente come una chiave che apra la porta di una strada non mai più calpestata da altri."

road (*la strada*) which led to an explanation of the tides based on the Earth's motion rather than on "occult qualities [...] and similar idle phantasies" (*qualità occulte e [...] simili vane immaginazioni*) had already been opened by one of Galileo's Pisan teachers, Andrea Cesalpino. It is worthwhile to dwell briefly on his theory.

In Chapter III 5 of *Peripateticae quaestiones* (Peripatetic Questions, 1571), Cesalpino, the famous professor of the University of Pisa, demonstrates the thesis that "the ebb and flow of the sea is produced by the motion of the earth and not of the moon" (*maris fluxum et refluxum ex motu Terrae non Lunae fieri*).[65] He discusses not only the motion of the waters but also that of the earth. Firstly, Cesalpino refutes the theory of the moon's influence on the movements of the sea. The observation of a correspondence between lunar motion and tides is the basis for the belief that there is a causal relationship between the former and the latter. Cesalpino argues, however, that if this were true the seas would always flow in the same direction, accompanying the moon, instead of having an alternate motion.

Secondly, the remote action is inexplicable. By what mystery would the moon act on water and not the intermediate elements fire and air (ordered according to the peripatetic doctrine of natural places)? "In fact [the moon] cannot move [the water] by itself, because there is no contact.[66] Or is it necessary to assume that there is a hidden virtue (*virtus quaedam occulta*) such as the one the magnet exerts on iron? But even in this case the *virtus* must communicate the motion through an intermediate motion.

Thirdly, Cesalpino deals with the theory that the moon acts on the waters through its light, which would cause heating (*calefactio*), expansion of the waters (*tumor*), and a consequent flow (*exundatio*). As we have seen, this was the theory considered most plausible by Pico. However, Cesalpino disagrees. If it were true, the same "sympathetic" action (*huiusmodi sympathia in aqua*) would have a greater effect on concentrations of water smaller than seas and oceans, as in the case of lakes and ponds: "in fact, that which is smaller is moved by the same force more easily."[67]

After clearing away the arguments based on the Moon's action, Cesalpino moves on to consider Aristotle's *Meteorologica* II 2, in which the origin of the tides is sought in the combination of two causes. The first is the massive entry of water from rivers into the sea, especially in the eastern Mediterranean Basin. The waters of the Mediterranean flow from east to west, from the Black Sea and the Aegean to the Tyrrhenian Sea. The second cause is an oscillatory balancing (*libratio*) of the waters: "another one is the measured oscillation/balancing of the entire sea which in fact often

[65] I discuss Cesalpino's theory in "Riflessioni sul moto terrestre nel Rinascimento."
[66] Cesalpinus, *Peripateticarum quaestionum libri quinque*, 60r: "Nam [Luna] se ipsa [aquam] movere non potest, quia non tangit."
[67] Ibid.: "quod enim minus est, ab eadem virtute facilius movetur."

oscillates [*libratur*]."[68] The parallel between the oscillatory motion of waters and the behavior of a balance, implicit in the concept of *libratio*, does not convince Cesalpino. If in fact the weight were greater in one part of the balance, it follows that there would not be a rebalancing of the distribution of the waters but rather a flow in a single direction:

> Aristotle assumes that the same balancing that occurs to a steelyard can be ascribed to the sea. If they receive an initial motion, they alternatively incline towards one side and the other, owing to the equality of the weights. Actually, if the weight on the one side would be greater, the whole would incline and would not be lifted back again.[69]

Cesalpino additionally observes that if the element of water encloses that of earth everywhere, there would be no explanation why an alternate motion like the one in question originates.[70] It could certainly not be a 'violent motion', according to the Aristotelian distinction between natural and violent motions. Indeed "nothing produced with violence is perpetual" (*nullum violentum sit perpetuum*).[71]

A similar and different criticism of the relevant passage of the *Meteorologica* is found in Telesio's *De mari* (vi-vii). Aristotle's *libratio* also does not seem plausible to him, "because the Earth is spherical, therefore it is impossible that its northern part, nor any other of its parts, can be higher or lower."[72] Hence the parallel of the balance scale is wrong, but even if one accepts such an absurdity, Telesio writes, one must consider the phenomenon of balancing and draw consequences that are different (both from Aristotle and from Cesalpino):

> If it has been inclined and no external force pushes nor moves it, it will remain forever at rest. Aristotle should strongly agree on this, as he upholds that all the elements [...] are at rest in their natural place and benefit from immobility.[73]

Let us return to *Peripateticae quaestiones*. According to Cesalpino's reasoning, there only remains one option: that the tides are an "incidental motion" dependent on the container (*continens*), which refers to the basins containing the seas. The extrinsic violent motion has already been excluded by

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[68] Ibid.: "alteram autem esse modicam quandam totius maris librationem: huc enim illuc libratur saepe."
[69] Ibid.: "Quod igitur stateris accidit aequilibris, mari vult contingere Aristoteles. Accepto enim principio motus inclinant modo in unam partem, modo in alteram saepe, propter aequalitatem ponderis. Nam si in altera parte pondus superaret, in eam totum vergeret, nec in alteram resurgeret."
[70] This is an old argument, used in antiquity by Strabo (basing himself on Archimedes) against Eratosthenes, supporter of a hypothesis similar to that of Aristotle mentioned here.
[71] Cesalpinus, *Peripateticae quaestiones*, 60r.
[72] Telesio, *De mari* vii, *ed. cit.*, 101: "Per che la terra è sferica, né può parere che la parte boreale, o qual si voglia altra sia più alta o più bassa."
[73] Ibid.: "Ma dove gli sia una volta declinato, quivi non essendo da alcuna forza esterna sospinto o mosso, rimarrà perpetuamente immobile; e questo debbe parere particolarmente ad Aristotile, al quale pare che tutti li primi corpi [...] sieno nel proprio loco immobili, e che della immobilità godino." Telesio's conclusion is remarkable in the context of the Renaissance *equilibrium controversy* over the behavior of balances that are displaced from their equilibrium as reconstructed in Jü Renn and Damerow, *Equilibrium Controversy*.

the observation that no violent action can last uninterrupted. However, he excludes the possibility that the seas tides could be "natural motions". According to Aristotle, each element has a unique natural motion and, in this case, the four elements would have a single downward or upward vertical tendency (or, better said, they would move either *toward the center* and *away from the center* of the elements) to return to their natural place. If the tides were a natural motion of the water it follows that this element has more than one natural motion. Thus having eliminated the explanation based on what Cesalpino calls a *per se* cause (the natural motion of the waters), Cesalpino investigates the incidental one, caused by the motion of the "container". The tides would result from the action of one of the two elements contiguous to the sphere of water, i.e. the air or earth. Since the only motion of air is the disordered one of the winds, which at best can ruffle the waters of the seas, Cesalpino infers that the motion of the tides depends on that of the earth. Q.E.D.: *maris fluxum et refluxum ex motu terrae fieri* (the ebb and flow of the sea is produced by the motion of the earth).

Cesalpino explains that the tides should be conceived in a manner similar to the behavior of water in a low, wide container in motion. At first the liquid in the container resists the motion, then follows it and quivers as if seeking its equilibrium:

> As one can see in a small vessel, which is more wide than deep, if it is moved the water first resists in the part opposite [to the direction of the motion] and often oscillates [*libratur*] here and there searching for its equilibrium. Thus, after the earth has moved a bit, the water, which has first remained behind and is out of balance, flows in the other direction, but surpassing the point of equilibrium as a consequence of the imparted motion. For the same reason, it returns back, in the opposite direction, and continues to do that in the search for an equilibrium, in which it can rest naturally.[74]

The next step is to identify the nature of the earth's motion, the necessity of which is evident from the discussion on the tides. Cesalpino observes that the movement of the container—meaning the earth—will cause greater agitations where the masses of water are greater, namely in the oceans. Consequently the frequency and amplitude of the tides will not be equal in all the seas: "from this it is evident that the tides do not always follow the moon."[75] Moreover the *circumvolutio* of the earth must be minimal (*parva tamen*), otherwise the marine fluctuations would be much greater than they appear. Such motion will have consequences on celestial phenomena, a *variatio stellarum fixarum,* which Cesalpino identifies in the millennial motions. According to him, the *theorica planetarum* (planetary theory) can do without the spheres placed by astronomers beyond the eighth one, or rather

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[74] Cesalpinus, *Peripateticarum quaestionum libri*, 60v: "[…] ut videre licet in parvo vase, cuius amplior sit latitudo quam profunditas: si enim dimoveatur, resistit aqua a tergo priusquam in opposita partem, et saepe huc atque illuc libratur quaerens aequilibrium. Cum igitur terra modice praetergressa fuerit, aqua autem posterius derelicta, extra suum aequilibrium existens, in alteram partem ruit, sed ultra aequilibrium ob acceptum motus principium. Inde iterum ob eandem causam in oppositam partem vergit, et saepe id facit, quaerens aequilibrium, in quo naturaliter quiescat."

[75] Ibid., 61r: "ex quibus etiam patet non ubique aestus insequi Lunae cursum."

those assigned, according to Peurbach, to the precession of the equinoxes and its irregularities (the so-called *titubatio* or *trepidatio*):[76]

> If the sea perpetually oscillates forth and back, it is necessary that the earth moves. If this is correct, it is necessary that the position [*aspectum*] of the fixed stars changes accordingly. It is the motion of trepidation, discovered by the astronomers in the eighth sphere, that most likely depends on the motion of the earth rather than on its own motion [of the eighth sphere]. Moreover, if this oblique and discontinuous motion of the earth is sufficient to account for the observed change of position [*aspectus*], one does not have to posit any other spheres above the eighth sphere.[77]

This is a moderate Copernican position. Of the three terrestrial motions postulated by Nicolaus Copernicus in *De revolutionibus orbium coelestium* (On the Revolutions of the Celestial Spheres, 1543), Cesalpino retains only the one that seems least plausible to the modern reader: neither the diurnal rotation nor the annual revolution but the third motion called *motus declinationis* which would account for the precession of the equinoxes, for the variability of the earth's axis as well as the presumed irregularities of the precession.

Thus Cesalpino's doctrine is a historical precedent of the Galilean theory of the tides. Galileo's basic thesis is very close to that of his teacher in Pisa, beginning with the experiment (whether mind experiment or not) of the 'vessel': "But if, by simply setting the vessel in motion, I can represent for you without any artifice at all precisely those changes which are perceived in the waters of the sea, why should you reject this cause and take refuge in miracles?"[78] The same applies to the conclusion: "[…] [Y]ou have explained very persuasively why it would be impossible for the observed movements to take place in the ordinary course of nature if the basins containing the waters of the seas were standing still […]."[79] Galileo and Cesalpino were both driven by a radical rejection of the lunar option, which introduced occult qualities and remote influences into physics. Galileo's anti-astrological rancor can be seen in the following passage concerning the monthly and annual periodicity of the tides, to be considered along with the daily periodicity:

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[76] I dealt with this topic in relation to Peurbach, Copernicus and Bruno in Omodeo, "Giordano Bruno and Nicolaus Copernicus," 49–51.

[77] Cesalpinus, *Peripateticarum quaestionum libri*, 61r: "Si enim libratur huc illuc mare perpetuo, necesse est terram moveri. Si vero hanc, necesse est aspectum stellarum fixarum variari. Motus ergo trepidationis ab astrologis inventus in octava sphaera, ex motu terrae rationabilibus contingit, quam ex motu illius. Si igitur parvus hic atque obliquus et inaequalis terrae motus sufficit ad mutationem aspectus, quae notata est, non sunt ponendi alii orbes supra octavam sphaeram."

[78] Galilei, *Dialogue*, 421. Cf. Galilei, *Le opere,* vol. 7, 447: "Ma se co'l far movere il vaso, senza artifizio nessuno, anzi semplicissimamente, io vi posso rappresentar puntualmente tutte quelle mutazioni che si osservano nell'acque marine, perché volete ricusar questa cagione e ricorrere al miracolo?"

[79] Ibid., 461. Cf. Galilei, *Le opere,* vol. 7, 486: "Molto concludentemente si dichiara, che stando fermi i vasi contenenti le acque marine, impossibil sarebbe, secondo il comun corso di natura, che in esse seguissero quei movimenti che seguir veggiamo."

> Now two other periods occur, the monthly and the annual. These do not introduce new and different events beyond those already considered under the diurnal period, but they act upon the latter by making them greater or less at different parts of the lunar month and at different seasons of the solar year—almost as though the moon and the sun were taking part in the production of such effects. But that concept is completely repugnant to my mind; for seeing how this movement of the oceans is a local and sensible one, made in an immense bulk of water, I cannot bring myself to give credence to such causes as lights, warm temperatures, predominances of occult qualities, and similar idle imaginings. These are so far from being actual or possible causes of the tides that the very contrary is true. The tides are the cause of them; that is, make them occur to mentalities better equipped for loquacity and ostentation than for reflections upon and investigations into the most hidden works of nature. Rather than be reduced to offering those wise, clever, and modest words, "I do not know," they hasten to wag their tongues and even their pens in the wildest absurdities.[80]

6. Pandolfo Sfondrati's middle way: the sun's heat as the cause of the tides

Alongside those who wrestled with vitalistic, peripatetic, or mechanical theories aimed at refuting the idea of a remote action of the moon, there were those who took the other path opened by Pico aimed at limiting the action of the heavenly bodies to motion, light, and heat. For example, a theory based on the action of the sun's heat was proposed by an eclectic atomist from Cremona, Pandolfo Sfondrati, in a work entitled *Causa aestus maris* (The Cause of Sea Tides). The first edition, now lost, must have appeared in Turin around 1582; a second was printed in Ferrara by the typographer Mammarello in 1590 with the *imprimatur* of the local Inquisition and the indication of approval of the preceding edition by the Inquisitor of Turin.[81] Hence the book appeared in the period between the first (1570) and second edition (1590) of Telesio's *opuscula*, during which time Cesalpino's *Peripateticae quaestiones* (1571), Bruno's *La cena de le Ceneri* (1584) and the third edition of Telesio's *magnum opus* (1586) were also published.

Sfondrati, linked to the Savoy court, belonged to a distinguished Cremonese family which, in the person of the Milanese senator Paolo Sfondrati, represented the Habsburg interests, that is those of Milan and of Philip II in Turin. Paolo's brother was Nicolò Sfondrati who, taking the name Gregory XIV, occupied the papal throne between 1590 and 1591. Pandolfo dedicated the second edition of *Causa aestus maris* to him.

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[80] Ibid., 445. Cf. Galilei, *Le opere,* vol. 7, 470: "Seguono ora gli altri due periodi, mestruo e annuo, li quali non arrecano accidenti nuovi e diversi, oltre a i già considerati nel periodo diurno, ma operano ne i medesimi con rendergli maggiori e minori in diverse parti del mese lunare ed in diversi tempi dell'anno solare, quasi che e la Luna e il Sole entrino in parte dell'opera e nella produzion di tali effetti: cosa che totalmente repugna al mio intelletto, il quale, vedendo come questo de i mari è un movimento locale e sensato, fatto in una mole immensa d'acqua, non può arrecarsi a sottoscrivere a lumi, a caldi temperati, a predominii per qualità occulte ed a simili vane immaginazioni, le quali *tantum abest* che siano o possano esser cause del flusso, che per l'opposito il flusso è causa di quelle, cioè di farle venire ne i cervelli atti più alla loquacità ed ostentazione, che alla specolazione ed investigazione dell'opere più segrete di natura; li quali, prima che ridursi a profferir sulla savia ingenua e modesta parola *Non lo so*, scorrono a lasciarsi uscir di bocca, ed anco della penna, qual si voglia grande esorbitanza."

[81] Sfondrati, *Causa aestus maris*, 44v: "Frater Vincentius Vaschinus de Calvisano Vicarius generalis Sanctiss. Inquisitionis Status Sereniss. Ducis Ferrariae, visa subscriptione Reverendi Patris Inquisitoris Taurini 1582, a quo probatum fuit opus in exemplari veteri, imprimatur."

In this book Sfondrati begins with eclectic positions in philosophy. He argues for the concordance between Plato and Epicurus in natural philosophy: "I found so much solidity in the teachings of the academics and the Epicureans as far as the natural causes are concerned that I would not move away from their schools [*gremium*]."[82] Using this background Sfondrati proposes an original heliothermal explanation of the tides. The centrality of the action of the sun's heat is emphasized from the first lines of the book, with recourse to a pseudo-epistemological comment on the term *aestum*: "They derive the word 'aestum', tides, from 'aer', air, and assume that it properly means warmth. From it derives the word 'aestas', summer."[83] Like Telesio, Sfondrati introduces the 'heliothermal' theory of the tides with the metaphor of a boiling pot in which the vapors caused by heat tend to move upward, producing a rising effect.[84]

Sfondrati hypothesizes that the tides are generated by the action of the sun on the water particles and thus the phenomenon should be considered in terms of changes in the mutual relations of the sun and the earth. This would result in a perpetual flow of the seas and oceans around the earth, a circular motion similar to that of the celestial revolutions: "The sea flows eternally, running through the entire terrestrial globe, with the same order of all celestial bodies."[85]

The contrary motion of the ebbing of the tides would be linked to the collision of the primary flow against barriers, particularly in the vicinity of straits. These would hinder the impetus of the waters and partly push them back, producing recoils strong enough to explain the eastward tidal ebb.[86]

7. Patrizi's appraisal of the debate about the tides

The major philosophical work by Francesco Patrizi, *Nova de universis philosophia* (A New Philosophy of the Universe, 1591, was published less than a year after the second edition of Sfondrati's *Causa aestus maris* by the same Ferrarese typographer; it was dedicated to the same patron, Pope Gregory XIV, and contained a broad discussion of the tides. Six chapters of *Pancosmia*

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[82] Ibid., 31v: "Me tantam naturalium causarum soliditatem in dogmatibus Academicorum et Epicureorum reperisse, ut ab eorum gremio discedere nequeam, nec nisi ad satietatem eorum aquis etiam, atque etiam ablutum, curare ad alios me conferre [...]."

[83] Ibid., 3r: "Aestum ab aere deductum volunt, et proprie calorem significare, unde etiam aestatem derivatam esse." Cf. ibid., 4r: "aestum non ab aere simpliciter, sed ab aere usto derivatum esse [...] quasi quaedam ebullitionem, unde aestatem, et per methaphoram aestum maris nominata esse videmus [...]."

[84] Ibid., 3r.

[85] Ibid., 8r: "Mare transiit universum terrarum globum perenniter currendo in orbem circulariter, eodem ordine quo sydera omnia." Cf. ibid., 28v: "[...] et ideo mare suo cursu, cursum stellarum ab aeterno imitatur."

[86] Ibid., cap. 3, *Causa vera aestus marini*, 8r-v: "Cum via illa a Natura fuerit constituta, per quam Mare transiens universum terrarum globum perenniter currendo in orbem circuiret, eodem ordine quo sydera omnia, licet partim velocius, partim tardius indesinenter volvuntur, per illasque [Magellanicas] fauces concitato cursu ad rapidi flumini instar ferantur, neque omnes uno impetu tantorum Marium undae, per angustas huiusmodi fauces partransire possint, coguntur ex fuga contrarii contra oppositas ex adverso aquas sequaces regurgitare, et cum unda palpitatione quam vocant, undam proximam impellat, de necessitate ad oppositas partes quantumvis remotas, aestus concitatur, maior aut minor iuxta oppositionis distantiam, et aquarum multitudinem."

(XXIV–XXIX) and the fourth book of *Nova de universis philosophia* (which followed *Panaugia*, *Panarchia,* and *Pansychia*) were devoted to the subject of waters and seas.[87] The specific topic of the tides was dealt with in Chapters XXVIII and XXIX.

Chapter XXVIII of *Pancosmia*, entitled "De maris affluxus et refluxus varietate" (Various [Opinions] on the Ebb and Flow of the Sea), is an overview of the positions expressed in the intense sixteenth-century debate. Patrizi reviews the extensive literature of his time starting with *De fluxu et refluxu maris* (1588) by the physician and natural philosopher Federicus Chrysogonus of Zadar.[88] Chrysogonus wrote about the variable periodicity of the tides, which he attributed to the combination of solar and lunar cycles and calculated starting from the conjunction of the two heavenly bodies. Patrizi considers Chrysogonus the first of a host of Aristotelians who followed the Greek philosopher more or less slavishly. They include the Paduan professor of mathematics Federico Delfino, the celebrated Giulio Cesare Scaligero, the natural philosopher Girolamo Borri, and the physician and astrologer Annibale Raimondo.[89]

Patrizi dedicates a separate discussion to Niccolò Sagri of Ragusa (Dubrovnik) and underscores his diligence and originality. This little-known Dalmatian had written a curious dialogue, *Ragionamenti sopra le varietà de' flussi del mare oceano occidentale* (Reasoning on the Variety of the Tides of the Western Ocean) (Venice, 1574), in which he tried to reconcile the doctrine of lunar traction, based on the analogy between the moon acting on the seas and the magnet attracting iron, and the mechanical doctrine based on the analogy between the tides and the oscillations of a balance:

> However, if one concedes that the opposite part does not have enough force as [to counterbalance] the moon, I affirm that the small amount of force that you concede will be sufficient to move the waters, if not much then at least a little bit [...]. This [imparted motion] added to the past motion of the moon acts like a magnet on a compass. As one observes, when the [compass] is moved, [it] also [keeps moving] after [the magnet] has been removed from its sight [and] would never stop moving, if the stone was shown to it from time to time in the appropriate manner [...]. The same occurs if one touches a balance with equal weights: it needs some time to stop, alternately rising on the one side and on the other.[90]

Patrizi also considers Sfondrati's text in his review of his predecessors' works but he dismisses it as unfounded. The interpretation of the tides as a phenomenon resulting from the contrasted impetus of

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[87] xxiv De aqua et mari; xxv De aquae rotunditate; xxvi An aqua et terra unum efficiunt globum; xxvii De maris universi motibus; xxviii De maris afluxus, et refluxus varietate; xxix De causis affluxus et refluxus maris.

[88] Chrysogonus, *De modo collegiandi, prognosticandi et curandi febres*.

[89] Cf. Delphinus, *De fluxu et refluxu aquae maris*; Borri, *Del flusso e reflusso del mare* and Raimondo, *Trattato… del flusso e riflusso del mare.* For an essential review of the fourteenth-century debate on the tides, see Ventrice, *La discussione sulle maree tra astronomia, meccanica e filosofia nella cultura veneto-padovana del Cinquecento* (1989).

[90] Sagri, *Ragionamenti sopra le varietà de i flussi et riflussi del mare oceano occidentale*, 90: "Tuttavia qualora si volesse concedere che la parte opposita non habbia tanta forza, quanto la Luna, almeno dico, con quella poca forza che mi concedete che lei habbia, bastaria far movere l'acque, se non tanto almeno poco manco [...] e questo sarebbe con l'aiuto del passato moto della Luna a guisa come fa la calamita nella bussola, che quando viene ad essere mossa, avanti che si fermi, come si vede, ancor che sia levata la pietra dalla sua vista, e se da tempo in tempo convenevole li fosse rimostrata, non si fermerebbe mai [...] siccome viene a uno trabucco, o bilanza, che sia toccata, e datali causa che tra pesi equalmente, prima che si fermi tarda assai, hora alzandosi d'una parte hora dall'altra [...]."

the waters, which would then be redirected eastward, seems to him implausible, indeed ridiculous.[91] Patrizi also rejects the atomistic-mechanical approach to the heliothermal theory of the tides. Indeed Sfondrati had proposed that the sun's heat has an impact on the water particles. Patrizi's rejection of Sfondrati's theory of the action of the sun's rays on the waters does not imply a rejection of Telesio's heliothermal theory. It only criticizes Sfondrati's mechanistic approach. As I will explain shortly, Patrizi reformulates Telesio's theory in vitalistic terms. In fact his opinion on Telesio is completely different from that of the other authors who had discussed the tides: Telesio is presented as the one who came closest to the solution of the problem.

Patrizi admired Telesio although he was also critical of various aspects of his philosophy.[92] Antonio Persio dedicated the opusculum *De mari* in the Venetian edition of the *Opuscula* (1590) to Telesio. The dedication began by recalling the common philosophical discussions:

> Very erudite Patrizi, you remember that, when we sojourned together in Venice, I often recommended to you Telesio's new philosophy and his approach to philosophy; I urged you to carefully read his natural books [...]. I was then glad to explain to you any passage that might be obscure to you and I solved your doubts and criticism whenever I could.[93]

Thus, Persio's dedication attested to an intellectual affinity and mutual respect between Patrizi and Telesio. It continues,

> When I prepared the new edition of his booklet on the sea—which he had first published and was now augmented with the addition of some writings of his pertaining to the same subject—I judged that no better father and patron than you, Patrizi, could be found. Therefore, I decided to entrust it to you.[94]

Therefore, it is not surprising that Patrizi discusses Telesio's tidal theory in *Pancosmia*. He looks favorably on *De mari*, appreciating more the theoretical and natural profundity underlying the explanation of the tides than the special solution which he partly rejects.

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[91] Patrizi, *Nova de universis philosophia*, 139v(b): "Paucos ante menses editus est liber, titulo *Cause aestus maris*, magno sane apparatu, sed cause redditu ut videtur et exitu ridiculo. Ait, omnes aquas ad quaslibet fauces naturali cursu properare. Oceanum, a Laboratoris terra, ad Magellanicas fauces decurrere. Tum etiam ab Oriente easdem ad fauces accurrere. Per quas cum transire nequeat omnis, inde retro regurgitat, et aestum, in Africa, atque Hispaniae littoribus excitat: aqua, aquam proximam impellente; et ea palpitatione in opposita parte intumescente. Sed quot nam horis, aut diebus, aut hebdomadibus, aut etiam mensibus ea palpitatio retrocedat? Cur item in proxima, faucibus illis Brasiliae ora tam parvum facit, in longiquissimis, Lusitano et aversus etiam Gallico, Britannico, ac Belgico? [...]."

[92] On the "friendly polemic" between Patrizi and Telesio and the involvement of Persio, see Puliafito, "Introduzione," xxxiii–xlv.

[93] Telesio, *Varii de naturalibus rebus libelli* [1590] (2012), 2r: "Meministi eruditissime Patriti, cum Venetiis commoraremur, me tibi novam Telesii Philosophian, ac Philosophandi rationem saepius commendare, et te hortari, ut libros eius de natura legere diligenter. [...] Ego igitur libenter, et obscura quaecunque tibi essent interpretabar, et obijcientium sese dubitationum scrupulos eximebam, quando poteram."

[94] Ibid., 2v: "Cum igitur libellum eius de mari ab ipso primum editum, atque aliquibus ex eiusdem scriptis ad eandem rem pertinentibus auctum, denuo imprimendum curarem, patrem ipsi, ac patronum nullo Patricio aptiorem invenire me posse existimavi, tuaeque idcirco ipsum fidei comendare decrevi."

> Telesio, that excellent man who dared to mint a new philosophy with the force of his ingenuity (and for this reason we admire him deeply) is the one who dealt with this issue in the most fitting manner. He affirms that [1] the sea is naturally warm and inclined to move whereby it is preserved and pleased; and [2] thereby it flees from the action of the sun in order to avoid excessive evaporation. The first affirmation is perfectly true. However, I reject the second.[95]

Patrizi accepts the basic thesis according to which the sea is warm by nature and as such is naturally led to undergo those motions that ensure its conservation. He does not accept, however, the explanation of the tides attributed solely to the action of the sun. Telesio's heliothermal theory is not able to explain why the sun does not act on all waters in the same way nor the difference in the behavior of salt and fresh waters in response to its radiation. It also cannot account for the fact that similar tides are found at different latitudes, which seems to be at odds with the variations in intensity of the solar rays.[96] Finally Patrizi criticizes Telesio's hypothesis because it assumes seasonal variations which do not exist.[97]

In conclusion, Patrizi rejects the theory that the tides are solely an effect of solar heat. He emphasizes above all the difficulty of matching the implications of the theory with the empirical evidence. He would not be the only one to make this criticism. For example, we can recall the much more corrosive polemic against the heliothermal theory of the tides advanced by Galileo in the *Dialogue*:

> As for those who make the temperate heat of the moon able to swell the water, you may tell them to put a fire under a kettle of water, hold their right hands in it until the heat raises the water a single inch, and then take them out to write about the swelling of the seas.[98]

8. Patrizi's vitalistic theory of the tides

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[95] Patrizi, *Nova de universis philosophia*, *Pancosmia*, 140r(b)-v(a): "Telesius vir ingens, qui proprii viribus ingenii novam cudere est ausus philosophiam, quem ea de re, nos maxime admiramur, quaestionem etiam hanc, omnium optime videtur perfecturus. Mare inquit [1.] sui natura calidum, pronum est in motum, quo et servetur, et oblectetur. Et [2.] quo solis actionem fugiat, ne ab eo usto plus solvatur in vapores. Pars prior verissima est [1.]. Secunda haec non placet [2.]."

[96] Ibid., 140v(a): "Cur enim omnia maria, ea fuga non cientur? Cur aquae dulces nullae? Cum et tenuiores sint, et solutu faciliores? Sed et causa haec communis motibus maris omnibus est. Fluxus vero et refluxus propriam dicit esse, quia sol in mari ingeneret vapores, qui egressum molientes, a mari superposito prohibiti, ipsum attollunt, et agitant. Idque vere et Autumno maxime, quia medius sol, plurimos crassioresque educit vapores. Sed causam reddat, cur in Aremoricis, et Belgicis, quae a medio sole longe distant, par aestus fit, ac in Taprobana, quae aequinoctiali et medio soli est subiecta? [...] Aestate inquit, minor sit, quia sol tenuissimos vapores gignit qui facile elabuntur, et ipsum non attollunt. At et aestate, aestus hic aeque attollitur, atque alias. Hieme item, inquit minus, quia sol languidissimus per paucos ingeneret, qui sint mare attollere impotentes. At et hoc salsum est, hieme aequalem aliis temporibus, aestum non fieri."

[97] Ibid.: "In Pleniluniis, inquit, maior, quia multa a luna resiliens lux, multos educit vapores. At quae nam lunae lux resilit, in nostra maria, cum luna est apud antipodas? In noviluniis, ait, quia refrigerato aere, internus maris calor, se se colligens, valentior factus, plures facit vapores et emittit. Sed si a superposito mari prohibiti egressu ipsorum attollunt, quo modo eos emittit? Et si emittit, quo modo egressu prohibentur, et attollunt? In lunae quadratis, addit, non multa a luna resiliente luce, nec proprio maris calore in se collecto, minime attollitur. At cur non saltem dimidio attollitur, ut et lux ei est dimidiata a plenilunio? Et calore dimidiate in se collecto? Hae fluxus ei viro causae funi. Refluxus vero hae aliae."

[98] Galilei, *Dialogues*, 420. Cf. Galilei, *Le opere*, vol. 7, 446: "A quelli del calor temperato, potente a far rigonfiar l'acqua, dite che pongano il fuoco sotto di una caldaia piena d'acqua, e che vi tengan dentro la man destra sin che l'acqua per il caldo si sollevi un sol dito, e poi la cavino, e scrivano del rigonfiamento del mare."

After discussing the hypotheses of his predecessors and his immediate interlocutors and having discussed Telesio's doctrine, Patrizi advances his own explanation in Chapter XXIX of *Pancosmia*, "De causis affluxus et refluxus maris" (On the Causes of the Ebb and Flow of the Sea).

Firstly, he pronounces against lunar causality alone.[99] The moon, he maintains, is not alone in presiding over the tides *in universale*. The sun is the life-giving principle that communicates warmth and life and renders earthly things able to move. The moon instead has a deep affinity with the earth, which explains the parallelism of its celestial motions and numerous terrestrial cycles. Nevertheless, Patrizi believes that the celestial bodies are universal causes (*causae universales*) and thus unsuitable to account for precise phenomena such as marine motions, for which it is necessary to identify the particular causes (*causae propriae*).

What then is the cause of the motion of the seas? Patrizi identifies it as an internal and vital impulse. In the same way in which the stars move about the ethereal heavens thanks to an autonomous impetus, like the birds in air and the fishes in water, the waters of our globe are moved by an intrinsic principle of life and movement.

> Why should we not allot this to the inner nature of the sea? In fact, just as we have taught that the stars are carried through the ether by their intellect, soul, and spirit, and that the planets, the sun and the moon, as well as the air below them, are carried by the same causes, in the same manner, why should it be a miracle that the sea is carried by its own nature in various directions not differently than the planets? Among those motions are the ebb and flow, [produced] by its own intellect, soul, and spirit.[100]

According to Patrizi, the moon and sun "impress" a motion on the waters but this relationship is not causal. Rather it is an approximation: the sea or the ocean mimics the celestial motions "but in its own way" (*sed suo modo*). The vital motion of the waters is precisely the *mimesis* and *variatio* of those of the sun and the moon.[101] The impulse to life implies the search for self-preservation. The tide is a kind of breathing of the living sea that is nourished by an alternating generative exchange with the shores:

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[99] Patrizi, *Nova de universis philosophia*, 141r(b): "Si Luna, uti aiunt, dux aquarum esset omnes aquas aeque duceret, non aliter ac igni, omnia comburitur ustilia. Sol omnes discutit tenebras, Luna ipsa omnia maria, omnes lacus, stagna omnia, amnes omnes, quando lucet, suo collustrat lumine, at non omnes ducit aquas. Non est erto aquarum omnium dux, non tractrix omnium, non avectrix."

[100] Ibid., 142*r*(b): "Sed quid vetat maris propriae naturae hoc tribuere? Nam sicuti stellas propria natura, ab intellectu, ab animo, a spiritu, in aethere ferti docuimus, planetas quoque eisdem causis ferti, solemque lunamque, et sub eis aerem, quid miraculi est, mare, quoque pluribus natura sua, non aliter, ac planetae motibus cieri? Inter quos et affluxus sit, et refluxus? Ab intellectu nimirum, ab animo, a spirito suo."

[101] Ibid., 142v(b): "A Luna ergo, et a sole in mare astrorum motus veluti imprimuntur, tum eorum quae perpetuo, uniformique circumeunt mundum motu, tum eorum, quae variis multiplicibusque feruntur; qualibus, et maria feruntur, et Oceanus. Sed suo modo. Nam illos quidem non assequitur, sed aemulatur. [...] Inesse autem plures salsedini spiritus, multa docent experimenta."

> If we only consider the ebb, which we have attentively observed on so many shores, the issue does not seem to be deprived of reason. In fact, in calm sea, [the water] shows a motion to and from the plane shore, at regular intervals, producing a continuous motion, which we have called a sort of respiration. While part [of the waters] moves back and flows down into lower places, another part arises, merges, passes over it and covers the shore. The first [wave], as if it grew shy and sought its own safety, hides itself in the belly [of the sea], impregnates itself and grows. Once it has grown it flows quicker to the shore. Thus, at regular intervals, a flowing forth and back is produced.[102]

The origin of this phenomenon is a process of rarefaction and boiling similar to the process of thermal expansion advanced by Telesio. The heating of the waters results from the combination of the heat proper to them and the life-giving action of the sun, moon, and stars.[103] The *causa propriissima* (the most direct cause), however, is an intimate impulse generated by the spirit inherent in the waters and concentrated in the salt. "Many experiences show that there are several spirits in that which is salty."[104] Hence the salt is the direct cause of the sea's motions and the phenomenon of the tides in particular:

> Saltiness—a nature that [the sea] does not share with any other [element]—is the most direct cause [*propriissima causa*] accounting for the variety of motions of the sea. In fact, no sweet water or water with another taste is moved in so many ways. Aside from the salty [water] none has an ebb and flow [...]. Saltiness is therefore the closest, internal, and most direct cause of the marine motions.[105]

On this basis, Patrizi is able to indicate a cause intrinsic to the waters which accounts for the phenomenon of waves and tides. At the same time he does not reject the importance of celestial causes acting *in universale* rather than *in particulare*. Indeed he proposes a vitalistic and thermal theory able to hold together and go beyond the astrological theories and the heliothermal ones. Concerning the link between marine phenomena and astronomy, Patrizi's perspective allows for the abandonment of astrological causality without losing sight of the cosmological framework:

> Through these motions the sea, which is like a terrestrial ether, imitates the motion of the ethereal stars.[106]

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[102] Ibid., 143v(b): "Nam si modus refluxus consideretur, quem nos in multis littoribus studiose spectavimus, non videbitur quaestio carere ratione. Namque tranquillo mari, moto eo, quem perpetuam quasi eius respirationem appellavimus, continue, et fluere, et refluere ad plana littora, tempore eodem conspicitur. Parti enim eius recurrenti, et ad humiliora refluenti, pars alia altior supervenit, et priorem illam obruit, eique superequitat, et super eam in littus currit. Illa, quasi timida, salutem sibi quaerens, in ventrem se obruentis, conditur; et se ipsa gravidam eam reddit, et altiorem facit. Haec altior facta, citatior ad littora affluit. Eodem igitur tempore, affluxus fit et refluxus."

[103] Ibid., 144r(a): "Dum vero bulliunt, et attolluntur, necessario rarescunt. Per ergo rarefactionem, quae attolluntur aquae, altiores se ipsis fiunt. Rarefactio autem, non nisi vacui atomis, quae omni (uti ostensum antea est) insunt aquae dilatatis, et maioribus redditis. A calore nimirum in vapores partes aquae soluta. Eodem hoc modo (nullum enim alium experientia ostendit ulla) necesse est mare intumescere, ob poros eius rarefactos, et in vapores aquae parte acta, ab insito maris calore, a Sole interdiu, a Luna etiam noctu, sideribusque concalefacto."

[104] Ibid., 142v(b): "Inesse autem plures salsedini spiritus, multa docent experimenta."

[105] Ibid., 142v(a): "Salsedo igitur propriissima est causa, nulli alii communis natura, cur mare tot motibus agitetur, nulla enim dulcis, nulla alterius saporis aqua, tot agitatur; nulla affluxum, et refluxum [...] patitur, praeter unam salsam. Salsitudo ergo motum marinorum proxima, et interna, et propriissima est causa."

[106] Ibid.: "Per hos motus, mare, quasi terrenus quidam aether, aethereos stellarum imitatur motus."

7. Concluding note

Telesio's tidal theory in *De mari* X–XIII is part of an extremely varied Renaissance discussion of the phenomenon. On the one hand, geographical explorations, colonial enterprises, and the needs of navigation expanded and diversified knowledge of the seas and oceans, ocean currents, straits, and tides. On the other hand, attempts at rational-empirical emancipation from astrology, which was increasingly seen as an occult, superstitious, and dubious doctrine from both the theoretical and ethical point of view, coincided with the search for new explanations of the tides, whose theory appeared to be refuted by some of the commonest astrological explanations. Particularly influential was the discussion by Albumasar, whose *Introductorium in astronomiam* contained pages and pages on the influence of the moon on the waters. The astrological treatise, a standard reference on the phenomenon in question, also dwelt on the exact relationship between the tidal cycle and lunar phases and on the variations of tides in relation to the changing positions of the sun and moon. After Newton, it would be understood that the basis of these correspondences between celestial motions and the tidal cycle was to be found in the law of universal gravitation, but for Albumasar's successors it was an astral influence. Indeed the celestial origin of the sea's motions was an indisputable empirical proof of the action of the stars on earthly events. In fact the origin of the explanation of the tides through the remote action of the sun and moon was astrological. By contrast, the philosophical, religious, and ethical criticism of astrology also included the rejection of the lunar or solar-lunar tidal theory and was faced with the challenge of indicating an alternative explanation of the tides. A clear testament to the link between criticism of the lunar theory and the rejection of astrology is Pico's *Disputationes*, which had a broad influence on the scientific rationalism of the Renaissance.

Although the theory of the remote attraction of the moon and sun continued to be followed throughout the sixteenth and seventeenth centuries, especially in university circles linked to Aristotelianism, there was a growing number of those subjecting this concept to severe criticism for the reasons just mentioned. Many scholars rejected the possibility of a remote action by means of a *cognata virtus* (as the interpreters of Albumasar called it), viewed as a *qualitas occulta* (in the terminology of the detractors). Very diverse natural philosophers and mathematicians, such as Giordano Bruno, Andrea Cesalpino, and Galileo Galilei, completely denied the possibility of a lunar influence. For them, in the best of cases one could speak of a parallelism whose reasons were to be sought in a common root of the phenomena and not in a direct causality of one with respect to the other. The complete renunciation of celestial causes led either to vitalistic explanations by which the seas are moved by an intimate vital impulse or to a mechanical explanation.

Other Renaissance authors tried to take a middle way. They accepted Pico's invitation to limit the action of the heavenly bodies to motion, light, and heat. For them, heat, not so much the lunar heat as the solar one, would be the cause (or a contributing cause) of waves and tides. This was the path taken not only by Bernardino Telesio but also by lesser-known thinkers such as the eclectic atomist Pandolfo Sfondrati.

In summary, four explanatory models of the tides merit our consideration as the ones dominating the Renaissance debate on this phenomenon:

1. The astrological approach in which the lunar, or lunar-solar, tidal theory makes use of the analogy of the magnet. The moon is a kind of movable pole that attracts water to itself. This idea remained firm in the scholastic and Aristotelian tradition, as shown by its longevity among scholars at the University of Padua.

2. Vitalistic explanations such as those of Bruno and Patrizi. If we wish to indicate a metaphor for this option, it would be that of the living organism whose movements are conceived as teleological impulses aimed at self-preservation. In this perspective, Patrizi considers the tides as a motion of breathing by the living sea whose movement mimics "in its own way" that of the heavenly bodies, which are also free within the heavens. It is curious to note that although Patrizi rejects Telesio's heliothermal tidal theory he retains a thermal explanation of the tides and ultimately bases his explanation on Telesian premises, in particular the assumption that the sea is intrinsically warm, thus apt to move, and that its motions respond to a principle of universal animation.

3. The mechanical explanations of those who consider the motion of the tides analogous to the oscillation of a balance scale or to the behavior of a vessel in movement which communicates its motion to the liquid it contains. This is the theory Galileo developed from premises set by his scholastic teacher Cesalpino.

4. The heliothermal explanation seeks to rationalize the celestial influence by reducing it to a heating action. The metaphor is that of boiling liquid in a pot. Telesio worked along this line of thought.

Within the pluralism of positions expressed in the Renaissance debate on the tides and in the variety of explanatory models (sometimes intertwined and not always clearly distinguishable from one another), the explanation with an astrological foundation is closest to the modern one. However, it has several limitations with respect to Newton's conclusions. For example, the remote action of the moon is not conceived in terms of gravitational attraction. It is irreducibly qualitative. Indeed the *cognatio* of moon and waters is qualitative; hence the *virtus tractrix* (tractive force) of the heavenly body is ascribed to an obscure essential affinity. Similarly, the combined influence of the moon and the sun is expressed in astrological terms such as conjunction, quadrature, and opposition. As mentioned above, the Renaissance detractors of this approach were not only worried about the elusive

nature of the recourse to occult powers and remote actions but also about the ethical implications inherent in the assumption that the heavenly bodies do not only act on the elements but also on human events and choices.

Johannes Kepler, who did not disdain astrology at all, was harshly rebuked by Galileo for his acceptance of the lunar theory of the tides:

> But among all the great men who have philosophized about this remarkable effect, I am more astonished at Kepler than at any other. Despite his open and acute mind, and though he has the motions attributed to the earth at his fingertips, he has nevertheless lent his ear and his assent to the moon's dominion over the waters, to occult properties, and to such puerilities.[107]

In truth, Kepler opened the way to modern celestial physics by laying the foundation for Newton's explanation. With all due respect to Galileo, it is no coincidence that a supporter of the Copernican system with astrological interests had to be the intermediary between the lunar theory of the tides and the modern gravitational explanation. In fact the heliocentric theory demolished the idea of the uniqueness of the center of gravity in the universe of Aristotelian physics and forced scholars to admit that there are many centers of gravity in the universe. This is an indispensable assumption for a theory of universal gravitation.

The Renaissance debates on the tides remind us that the historical developments of empirical and rational science travelled along roads that were anything but straight. The plurality of opinions and theories about the tides presents an inextricable tangle of philosophical, ethical, and methodological views in which the link between scientific theories, rationality, and experience is extremely complex. Telesio's discussion in *De mari* fits precisely in the core of a debate in which both the precursors of modern scientific rationality and the discredited heirs of doctrines destined to marginalization and decline, such as astrology, contributed to the discovery of the fundamental laws of nature.

[107] Galilei, *Dialogues*, 462. Cf. Galilei, *Le opere,* vol. 7, 486: "Ma tra tutti gli uomini grandi che sopra tal mirabile effetto di natura hanno filosofato, più mi meraviglio del Keplero che di altri, il quale, d'ingegno libero ed acuto, e che aveva in mano i moti attribuiti alla Terra, abbia poi dato orecchio ed assenso a predominii della Luna sopra l'acqua, ed a proprietà occulte e simili fanciullezze."

7.

In Search of the True Nature of the Rainbow: Renewal of the Aristotelian Tradition in the Renaissance and the *De Iride*.[108]

Elio Nenci

From the point of view of the history of science the discussion about how the rainbow is formed is one of the most interesting sections of Aristotle's philosophy of nature (*Meteorologica*, Book 3, Chapter 4). This chapter clearly shows that for Aristotle the explanation of a natural phenomenon cannot be reduced to its mathematical formulation but must consider the whole of the changes that take place during its production. In this case, Aristotle acknowledged the need to resort to mathematics in order to single out the cause of the rainbow. Therefore, he did not hesitate to make use of the results obtained by the contemporaneous science of optics, but he also had to go beyond them since one of the essential aspects of the phenomenon, color, seemed to have been almost ignored in the exact mathematical studies made by the scientists of that time.

With regard to this point, it is relevant to refer to questions extensively dealt with in other Aristotelian works. In the first place, we must refer to the discussion about the so-called "sciences subordinated to mathematics" which takes place in the *Analytica Posteriora* (I.9, 76a9–25 and I.13, 78b36–79a10). These "subordinated sciences", which included optics and harmonics, were devoted to some natural phenomena by assuming principles taken from geometry and arithmetic. These principles explained the cause of a phenomenon by specifying the *reason why* (διότι) it took place, whereas the fact *that* (ὅτι) it took place, i.e. *what* it was, was the object of the subordinated natural science. So the science of harmony studied sounds by expressing them as simple numerical ratios and optics did the same thing for vision by using lines, angles, and triangles.

From this point of view, the case of the rainbow was even more interesting because it was an example of "double subordination". On the one hand, its causes had to be explained by means of optics (*An. Post.*, I.13, 79a10–16);[109] on the other hand, this "science subordinated to geometry" was then based on the theory that the visual rays were expelled from the eye, and this theory was openly in contrast with what Aristotle maintained in the *De anima* (II.7, 418a29–418b14) and in the *De sensu et sensibilibus* (2, 438b2–8): namely, that vision takes place through a change of a *diaphane* (διαφανὲς), i.e. of a transparent substance (such as air, water, etc.), of which light is the activity. By *diaphane* Aristotle meant that which is visible by means of an alien color. Color was considered the

[108] For a classic account on this topic see Boyer, *Rainbow*.
[109] Brunschwig, "Aristote et le statut épistémologique de la théorie de l'arc-en-ciel."

"proper sensible" of vision and it was also one of the properties or characteristic qualities of the rainbow. Therefore, the theory of colors developed in Chapter 3 of the *De sensu et sensibilibus* had to play an important role in the explanation of the natural phenomenon of the rainbow.

It is easy to understand why the discussion on the rainbow raised a series of philosophical problems within the Aristotelian tradition. Through the Middle Ages the study of this section of the *Meteorologica* was a source of difficulties for commentators who had to deal with an optical science which was much more advanced than the knowledge of optical phenomena available at the time of Aristotle. Thanks to the progress made by *Perspectiva* it was possible for medieval philosophers to study the optical 'causes' of the rainbow on different foundations, in particular because of the greater importance given to the phenomenon of refraction. We just have to mention Theodoric of Freiberg's (ca 1250–ca 1310) *De iride et de radialibus impressionibus* to give an idea of the impressive progress made in this field.[110]

On the other hand, the important results obtained by Theodoric remained unknown to later generations of philosophers, who largely continued to follow the way in which Aristotle dealt with the problem of the rainbow. This long tradition of comments on the *Meteorologica*, which from the 13th century was part of the *curriculum studiorum* of the main universities in Europe, was disturbed by the reappearance of the *Commentaries* on the *Meteorologica* written by Alexander of Aphrodisias (2nd–3rd century CE)[111] and by Olympiodorus (6th century CE).[112] During the first half of the 16th century, scholars who dealt with still unsolved problems on new foundations, often in contrast with the medieval tradition, mainly referred to these works. Nevertheless, the results of these new studies did not cause the science to progress any further.

In this essay I shall select works by Alessandro Piccolomini (1508–1578)[113] and Francesco Vimercati (1512–1571)[114] to illustrate the distinction between mathematics and natural philosophy, which was peculiar to the Aristotelian way of dealing with the rainbow. The discussion of these works will provide a background against which I shall analyze the work of Bernardino Telesio more precisely (1509–1588).[115]

1. Aristotle's Treatment of the Rainbow in the Meteorologica

[110] Theodoric of Freiberg, *De iride*.
[111] Alexander of Aphrodisias, *In Aristotelis meteorologicorum libros commentaria*, in *Commentaria in Aristotelem Graeca [CAG]*, vol. 3,2. Id., *In quatuor libros meteorologicorum Aristotelis commentatio*.
[112] Olympiodorus, *In Aristotelis meteora commentaria*, in *CAG*, vol. 12,2. Id., *In meteora Aristotelis commentarii* (1551).
[113] Piccolomini, "Tractatus de Iride." On Piccolomini's scientific works see Suter, "Scientific Work of Alessandro Piccolomini." For his participation in scientific disputes see Giacobbe, "Il Commentarium de certitude mathematicarum disciplinarum," Ferraro, "Dimostrazioni matematiche e conoscenza scientifica," Biard, "La certitude des mathématiques."
[114] Vimercati, *In quatuor libros Aristotelis Meteorologicorum commentarii*. On Vimercati see *Gilbert*, "*Francesco* Vimercato of Milan."
[115] Telesio, *Liber de iride* (1590). See also id., *De rerum natura* (1586), chapters 10–15.

Before going further, I think it will be useful to summarize Chapters 4 and 5 of Book 3 of the *Meteorologica*. In Chapter 2, Aristotle had already dealt with haloes, rainbows, mock suns or parhelia and rods.

> The complete circle of a halo was often visible round the sun and moon and round bright stars, and as frequently by night as by day […]. The rainbow never formed a complete circle, nor a segmental circle larger than a semicircle. […] After the autumn equinox it occurred at all hours of the day; but in summer it did not occur round about midday. No more than two rainbows occurred at the same time; of two such simultaneous rainbows each is three colored, the colors being the same in each and equal in number, but dimmer in the outer bow and placed in the reverse order. For in the inner bow it is the first and largest band that is red, in the outer it is the smallest and closest to the red band of the inner. […] The cause of all the phenomena was the same, for they were all phenomena of reflection [ἀνάκλασις]. They differed in the manner of reflection and in the reflecting surface, and according as the reflection was to the sun or some other bright object (*Meteor.* III.2, 371b22–25, 371b26–27, 371b30–372a5, 372a17–21).[116]

From the last part of this quotation it seems that Aristotle followed the theory of those writers on optics who explained vision by means of visual rays coming out of the eye. According to this theory, the rainbow was produced by a reflection of visual rays towards the sun. Our vision is reflected from substances which have a smooth surface, just like it is from water. In some mirrors, shapes are reflected, and in others only colors. "Colors are only reflected in mirrors that are small and incapable of subdivision by our sense of sight" (*Meteor.* III.2, 372b1–3). For the rainbow, the small mirrors were the little drops of water hanging in some clouds. But how to explain the genesis of colors?

In Chapter 3 of *De sensu et sensibilibus*, Aristotle reviews several hypotheses (1–2) and presents his own solution (3).

> (1) Firstly, white and black may be juxtaposed in such a way that by the minuteness of the division of its parts each is invisible while their product is visible; and thus color may be produced. This product can appear neither white nor black, but, since it must have some color and can have neither of the above two, it must be a sort of compound and a fresh kind of tint. In this way, then, we may conceive that numbers of colors over and above black and white may be produced, and that their multiplicity is due to differences in the proportion of their composition; […] and colors may, indeed, be analogous to harmonies. […]
> (2) This is one of the ways in which colors may be produced; a second is effected by the shining of one color through another. This we may illustrate by the practice sometimes adopted by painters when they give a wash of color over another more vivid tint […].
> According to the theory of juxtaposition, just as we must assume that there are invisible spatial quanta, so must we postulate an imperceptible time to account for the imperceptibility of the diverse stimuli transmitted to the sense organ, which seem to be one because they appear to be simultaneous. But on the other theory there is no such necessity; the surface color causes different motions in the medium when acted on and when not acted on by an underlying tint.
> (3) But let us premise that substances are mixed not merely in the way some people think – by a juxtaposition of their ultimate minute parts, which, however, are imperceptible to sense – but that they entirely interpenetrate each other in every part throughout; […]. On the other hand, things which cannot be resolved into least parts, cannot be mingled in this way; they must entirely interpenetrate each other; and these are the things which most naturally mix. […] Now, all this being so, it is clear that when substances

[116] Aristotle, *Meteorologica* (1952), 241–245.

> are mixed their colors too must be commingled, and that this is the supreme reason why there is a plurality of colors; neither superposition nor juxtaposition is the cause. In such mixtures the color does not appear single when you are at a distance and diverse when you come near; it is a single tint from all points of view (*De Sensu et Sens*. 3, 439b21–29, 439b32–33, 440a7–10, 440a22–28, 440a34–440b3, 440b10–13, 440b14–19). [117]

From the idea of *mixtio* (μίξις), one could have asked whether the black and white present in any color were related by numerical ratios, or whether one was predominant over the other; then ask to what extent such predominance could be determined more precisely through mathematics. From what Aristotle writes in Chapter 6 of *De sensu et sensibilibus*, it is clear that the infinite divisibility of the *mixtio* implies insurmountable limitations to visual perception, i.e. that which is extremely small could not be perceived unless it is placed within something sufficiently large; only in this case, from being potentially visible it will become actually visible (*De Sensu et Sens*. 6, 446a4–15).

Given these insurmountable limitations, we can formulate our question in a new way: how far can a natural philosopher go in his attempt at mathematicizing reality, when he needs to resort to mathematics in order to explain the causes of some phenomena? If, in the case of the rainbow, Aristotle did not go as far as that, this is probably a consequence of the nature of optical science in his time: it seems that those who dealt with optical problems only discussed colors in connection with other questions, such as the formation of reflected images in small mirrors or the ratio between the increased distance from the seen object and the augmented darkness. Increased distance naturally caused the exact perception of color to become lost.

For Aristotle the "proper sensible" of sight could never become the object of a purely mathematical investigation. This was true even in the case of the rainbow, although essential aspects of it were related to quantitative considerations.

The colors of the rainbow were formed by the reflection of the visual rays coming out of the eye in the little drops hanging in some clouds; these little drops were like small mirrors, and when the cloud, the sun, and the observer were arranged on the same line (with the observer in the middle) the little drops reflected the visual rays towards the sun, so as to present an altered image of the color of this bright body. This alteration was caused by the visual ray meeting the substance of the cloud—water—which is dark by nature. According to the formation of color, which I have previously described, the sunlight operated as the white and the cloud as the black.

However, how to explain the formation of the three colors of the rainbow and their order? In addition, why, in the double rainbow, was the external one less bright and why were the colors arranged differently? All these questions must be dealt with in the theory of *mixtio*, which must follow

[117] Aristotle, *De sensu and De memoria*, 57, 59–61.

the rules of optical science, according to which the theory of vision was treated in a geometrical manner. Aristotle answered the first of these questions in Book 3, Chapter 4 of *Meteorologica*:

> Bright light shining through a dark medium or reflected in a dark surface (it makes no difference which) looks red. Thus one can see how the flames of a fire made of green wood are red, because the fire-light which is bright and clear is mixed with a great deal of smoke; and the sun looks red when seen through mist or smoke. The reflection which is the rainbow therefore has its outermost circumference of this color, since the reflection is from minute water-drops. […] We must, as has been said, bear in mind and assume the following principles. (1) White light reflected on a dark surface or passing through a dark colored medium produces red; (2) our vision becomes weaker and less effective with distance; (3) dark color is a kind of negation of vision, the appearance of darkness being due to the failure of our sight; hence objects seen at a distance appear darker because our sight fails to reach them. […] At any rate, they give the reason why distant objects appear darker and smaller and less irregular, as do also objects seen in mirrors, and why too the clouds appear darker when one looks at their reflection in water than directly at them. This last example is a particularly clear one: for we view them with a vision diminished by the reflection. […] The reason is clearly that, just as our vision when reflected through an angle and so weakened makes a dark color appear still darker, so also it makes white appear less white and approach nearer to black. When the sight is fairly strong the color changes to red, when it is less strong to green, and when it is weaker still to blue (*Meteor*. III.4, 374a3–10, 374b9–15, 374b17–22, 374b28–33).[118]

As we have seen, the increased darkness of the bright color of the sun, and the formation of the colors of the rainbow which follows from it, is mainly caused by the reflection taking place in the little drops, which act as small mirrors.

Which mathematical aspects of reflection are relevant here? The increased distance of the reflected visual ray compared to direct vision certainly is. However, one must be careful not to regard the phenomenon as solely caused by the different distance and not to strictly apply this explanation to the other examples reported by Aristotle.

Alessandro Piccolomini, in his "Tractatus de iride" published as an appendix to his Latin translation of Alexander of Aphrodisias's *Commentaries* on the *Meteorologica*, thinks that such negligence would be wrong, for if the reflected vision of a cloud in a mirror or on the surface of water is represented by a geometrical figure, one gets two sides of a triangle, whereas the third side corresponds to the direct vision. Now it is true that two sides of a triangle are always bigger than the other side (Euclid's *Elements*, Book 1, prop. 20), but in this case the side corresponding to the visual ray, which goes from the eye to the reflecting surface, is negligibly small compared to that which goes from this surface to the cloud. Hence, one can regard it as minimally affecting the formation of color. According to Vitelo's measurements reported in his *Perspectiva*, clouds can reach a height of between three and five German miles (ca. 5900–7400 meters), whereas the observer's distance is at most four feet (Roman feet ca 30 cm).[119]

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[118] Aristotle, *Meteorologica*, 255–257, 259, 261.
[119] Piccolomini, "Tractatus de iride," 121.

In the Aristotelian framework, it was more difficult to establish the cause of the subsequent formation of three colors: red, green, and blue (violet). The slightly weakened view of the original color changed into a view that was increasingly weak. Was the increased distance a sufficient cause for this weakening of the view? And even if this were true, would it have been possible to exactly determine this variation? Aristotle tackled these problems thus:

> In the primary rainbow the outermost band is red. For the vision is reflected most strongly on to the sun from the largest circumference, and the outermost band is the largest: and corresponding remarks apply to the second and the third bands. […] This, then, is why the rainbow is three-colored and why the rainbow is made up of these three colors only. The same cause accounts for the double rainbow and for the colors in the outer bow being dimmer and in the reverse order. For the effects here are the same as those produced by an increase in the distance of vision on our perception of distant objects. The reflection from the outer rainbow is weaker because it has farther to travel; its impulse is therefore feebler, which makes the colors seem dimmer. The colors are in the reverse order because the impulse reaching the sun is greater from the smaller and inner band; for the reflected that is closer to our sight is the one reflected from the band that is closest to the primary rainbow, that is, the smallest band in the outer rainbow, which will consequently be colored red. And the second and third bands are to be explained analogously (*Meteor*. III.4, 375a2–4, 375a28–375b9).[120]

In the primary rainbow, Aristotle regards the extension of the bands of colors as the main cause of the weakened vision without considering the variation of distance. However, in the external rainbow he regards the increased distance as the main cause, and seems to put this in relation to the augmented width of the angle of incidence, which according to the optical theories would explain the weakened view through increased departure from the perpendicular.

It seems that these two different explanations could only be reconciled in the case that there was not always a direct relationship between increased distance and weakened view. One could imagine a visual power which kept the same strength up to a certain distance and then quickly weakened. Before that happened, the intensity of the vision would be caused by the small mirror, whereas later the increased distance, or more probably the increased width of the angle of incidence, would be the main cause.

2. Ancient Commentaries on Aristotle's Theory

Aristotle's passage on the rainbow raises a real problem. It seems that he was satisfied with the result that he had obtained, but later commentators did not seem to be equally satisfied. Alexander of Aphrodisias relates that some authors regarded the second rainbow not as a reflection of the visual rays towards the sun but as an image of the internal rainbow reflected in a cloud placed outside the

[120] Aristotle, *Meteorologica*, 261, 265.

first one.[121] It is likely that this argument was meant to explain the space without color between the two rainbows. Aristotle never pointed out this discontinuity between the two bands of red, but later, as reported by Alexander in his *Commentaries*, some other authors wondered why the empty space between the rainbows was not red, though it was nearer the larger band of the internal rainbow than the first band of the external rainbow.[122] Would not the reflection of the visual rays also show the same color in this part of the clouds? The little information given by Alexander may suggest that once more the difficulty should be dealt with on the basis of optical science, which taught that reflection should not occur from just any position: view, reflecting surface, and bright body ought to have specific positions and distances.[123]

Alexander of Aphrodisias's work was very influential in the Renaissance, as can be deduced from the frequent reprinting of Piccolomini's Latin translation. However, no solution could be found in it for the difficulties raised by Aristotle's text.

Olympiodorus's *Commentaries* on the *Meteorologica* are a different case, as they introduced a new element in the explanation of the formation of the rainbow's colors: they placed the clouds reached by the visual rays at different distances. The appearance of the three colors of the rainbow would depend both on the distance travelled by the visual rays and on the length of the distance covered inside the cloud. According to this point of view, when our vision meets the nearest clouds, it would have travelled a shorter distance and therefore would be stronger, whereas at the same time it would absorb a small quantity of the darkness of the water, thus causing the appearance of red.[124]

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[121] Alexander of Aphrodisias, *In quatuor libros meteorologicorum*, 81: "Aliqui quidem igitur dicunt, quod secunda iris, non per refractionem ad Solem fieri accidit, sed ad ipsam praeinexistentem iridem. Ita quod usus ipse ad exteriori nube, quae simili quidem modo disposita ad refractionem sit, sicut et prima, in qua prima iris est, ad praeinexistentem iridem refrangatur, et ex tali refractione secunda iris appareat; quapropter et languidiores sunt secundae iridis colores, tanquam ex secunda rursus refractione producti." *CAG*, vol. 3,2, 159, 9–15: τινὲς μὲν οὖν φασι τὴν δευτέραν ἶριν οὐ κατὰ τὴν πρὸς τὸν ἥλιον ἀνάκλασιν ἔτι γίνεσθαι, ἀλλὰ κατὰ τὴν προϋπάρχουσαν ἶριν, ὡς τῆς ὄψεως ἀπὸ τοῦ ἐξωτέρου νέφους ὁμοίως ἔχοντος, ὡς εἶχε καὶ τὸ πρῶτον, ἐφ' οἷς ἡ ἶρις, ἀνακλωμένης ἐπὶ τὴν προϋπάρχουσαν ἶριν, καὶ διὰ τῆς ἀνακλάσεως ἐκείνην ὁρώσης· διὸ καὶ ἀμαυρότερα τὰ χρώματα τὰ τῆς δευτέρας, ἅτε ἀπὸ ἀνακλάσεως γινόμενα δευτέρας.

[122] Ibid.: "Quaeret autem aliquis, nam si minor peripheria exterioris iridis phoeniceum colorem habet, quae prope ampliorem primae iridis peripheriam est, quae et ipsa per simile colorem retinet; propterea quia ab ambabus his peripheriis, fortior fit refractio visus ad Solem; quid nam, non et quod intermedium istarum peripheriarum est omne phoeniceum etiam habet colorem?" *CAG*, vol. 3,2, 160, 21–26: ἐπιζητήσαι τις ἄν, εἰ ἡ ἐλάττων περιφέρεια τῆς ἐξωτέρας ἴριδος φοινικοῦν ἔχει τὸ χρῶμα, οὖσα πλησίον τῆς μείζονος περιφερείας τῆς πρώτης ἴριδος, ἢ καὶ αὐτὴ τοιοῦτον ἔχει τὸ χρῶμα τῷ πλείους ὄψεις ἀπὸ τούτων ἀνακλᾶσθαι πρὸς τὸν ἥλιον, τί δήποτε οὐχὶ καὶ τὸ μεταξὺ τῶν περιφερειῶν τῶν εἰρημένων πᾶν φοινικοῦν ἔχει τὸ χρῶμα.

[123] Ibid., 81: "An neque ex qualibet quidem parte refrangi habet visus, secundum opinionem eorum qui sic visionem fieri existimant; neque ab omni parte refrangi habet lumen ad visum, secundum aliorum opinionem, qui sic fieri visionem arbitrantur? Verum determinata ac definita sunt loca refractionum, ac praefinitam distantiam esse oportet luminosi ipsius corporis a speculis ipsis, quae suspicere eius lumen habeant. Quapropter ab his quidem refractio accidit fieri, quae huiusmodi determinatum habeant situm." *CAG*, vol. 3,2, 160, 28–33: ἢ οὔτε ἀπὸ παντὸς μορίου ἡ ὄψις ἀνακλᾶται καθ' οὓς οὕτως τὰ τοιαῦτα ὁρᾶται, οὔτε ἐπὶ τὴν ὄψιν ἀνακλᾶται τὸ φῶς ἀπὸ παντὸς μορίου καθ' οὓς οὕτω τὸ ὁρᾶν, ἀλλ' ὡρισμένοι οἱ τόποι τῶν ἀνακλάσεων καὶ δεδομένην χρὴ τὴν ἀπόστασιν εἶναι τοῦ τὸ φῶς ποιοῦντος σώματος ἀπὸ τῶν δεχομένων αὐτὸ κατόπτρων· ἀπὸ τούτων οὖν γίνεται, ἃ ταύτην τὴν θέσιν ἔχει.

[124] Olympiodorus, *In meteora Aristotelis*, 65r: "Nubes enim, in quibus iris faciem ostendit suam, quia in exilia corpuscula minutaque stillicidia divisae discerptaeque sunt; et quaedam ipsarum longe ab oculis abductae iacent, quaedam vero propius consistunt; radii oculorum qui plurimi sunt, foras emissi ad regionem nubis quidam incursu suo propioribus nubibus obvii ad id quod apparet, reflectuntur hoc est ad Solem; quidam autem radii quibusdam a conspectu procul summotis

Though interesting, this new explanation would introduce an idea of *mixtio*, which in this case depends on the portion of the cloud traversed by the visual rays. Would it not be possible to solve the problem by explaining the phenomenon with a changing angle of incidence? According to Olympiodorus, vision became ever more weak the more the rays of the visual cone departed from its axis, i.e. from the ray that met the reflecting surface along a perpendicular line. Now in the case of the double rainbow the perpendicular rays and those nearest to it fell precisely between the two bands of red, that is in the space where no color was perceived. The strength of these rays could make it possible to perceive sunlight without any alteration. By moving away from this space, the visual rays were making the angle of incidence wider and wider, so that the perception of the different colors of the rainbow placed at the right, and the left of the space taken up by the rays near the perpendicular, became weaker. In this way, both the contrary order of the arrangement of the colors in the two rainbows and the space without color could be explained.[125]

However, would it have been possible to combine the two theories on the formation of color, one that refers to the portion of the cloud crossed by the visual rays and the other that uses the variation of the angle of incidence of the same rays? It would seem a simple affair, but Olympiodorus did not explore the problem further.

3. Piccolomini's and Vimercati's Assessments of Aristotle's Rainbow Doctrine

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nubibus incidunt; alii autem in alias ab oculis multo quoque adhuc remotiores nubes incurrunt. Sed radii quidem qui ad propiores nubes perveniunt, et quasi per exiguum nigrum, idest per nubilium aera ipsum aspiciunt Solem, non multum falluntur, quippe qui neque multum via defessi languent, et per brevia aeris nubilia ipsum cernunt. Ideoque phaeniceam Solis faciem in nubibus iis intuentur…" *CAG*, vol. 12,2, 236, 24–33: ἐπειδὴ γὰρ τὰ νέφη, ἐν οἷς ἡ ἶρις ἐκφαίνεται, κατακεκερματισμένα ἐστὶν εἰς μικρὰς ῥανίδας καὶ τὰ μὲν αὐτῶν πόρρω κεῖνται τῆς ὄψεως, τὰ δ'ἐγγυτέρω, αἱ ἐκ τοῦ ὄμματος ἐπ' αὐτὸ ἐκπεμπόμεναι ἀκτῖνες πλεῖσται οὖσαι αἱ μὲν εἰς τὰ πλησίον νέφη προσπίπτουσαι ἀνακλῶνται πρὸς τὸ ὁρατόν, τουτέστι τὸν ἥλιον, αἱ δὲ εἰς τὰ πορρωτέρω, αἱ δὲ ἔτι εἰς τὰ πορρωτέρω. ἀλλ'αἱ ἀλλ' αἱ μὲν εἰς τὰ πλησίον νέφη προσπίπτουσαι ἀκτῖνες ὡς ἂν δι'ὀλίγου μέλανος ὁρῶσαι αὐτόν, τουτέστι ἀχλυώδους ἀέρος, οὐ πάσχουσι πολλὴν τὴν ἀπάτην ἅτε δὴ μὴ πάνυ ἀσθενήσασαι καὶ δι'ὀλίγης ἀχλύος αὐτὸν ὁρῶσαι. ὅθεν φοινικοῦν χρῶμα ὁρῶσιν αὐτὸ τοῦ ἡλίου ἐν τοῖς νέφεσιν ἐκείνοις.

[125] Olympiodorus, *In meteora Aristotelis*, 65v: "Quum enim a visu nostro radii multi defluant, qui in rectam lineam ad rem spectabilem immittitur radius, qui itidem axis est cuiuslibet coni geniti, valentiorem et perspicaciorem videndi vim habet quam reliqui radii, qui non in rectam sed in obliquam partem perferantur. Et ex his rursum radiis qui recto et perpendiculari radio propiores sunt, videndo magis pollent quam qui a perpendiculari longius decidunt; ex quo fit, ut radius ad libramentum immissus quum validissimus omnium existat, nullum in videndo mendatium patiatur. […] Caeteros vero radios perpendiculari confines mendatium et fraudem pati certe contigit, sed exiguam. Hos vero qui longius ab eo radio qui axis cuislibet coni est, absistunt, in magnum mendacium et errorem incurrere. Iis rebus ita constitutis in iride nubes multi ab oculis emissi radii circumquaque oberrare videntur; quorum quidem radiorum unus in rectum emissus perpendicularis existit, aliqui autem huic proximi adiacent, alii procul a recto decidunt. Sed radius ad libramentum iniectus medio inter utrunque arcum spatio incidit in eum scilicet locum, qui inter utrasque phaeniceas lineas media regione interiacet, quo quidem in loco nullius mendax omnino coloris similitudo apparet." *CAG*, vol. 12,2, 238, 20–30: ἐπειδὴ γὰρ ἐκ τοῦ ὄμματος πιπτουσῶν ἀκτίνων ἡ κατὰ κάθετον φερομένη πρὸς τὸ ὁρατόν, ἥτις καὶ ἄξων ἐστὶ τῶν γινομένων κώνων, ἰσχυροτέρα ἐστὶ τῶν μὴ κατὰ κάθετον, ἀλλὰ πλαγίων φερομένων (καὶ τούτων αἱ πρὸς τῇ καθέτῳ ἰσχυρότεραί εἰσι τῶν πόρρω τῆς καθέτου), συμβαίνει τὴν μὲν κάθετον ὡς ἰσχυροτάτην οὖσαν μὴ πάσχειν ἀπάτην ἢ σπανίως ἔχειν, τὰς δὲ πρὸς τῇ καθέτῳ πάσχειν μὲν ἀπάτην, ὀλίγην δέ, τὰς δὲ πόρρω πολλὴν πάσχειν ἀπάτην. τούτων οὕτως ἐχόντων ἐπὶ τῆς ἴριδος φαίνονται ὄψεις πολλαὶ παρὰ τὰ νέφη, ὧν ἡ μέν ἐστι κάθετος, αἱ δὲ παρὰ τὴν κάθετον πίπτουσιν, αἱ δὲ πόρρω τῆς καθέτου. ἀλλ' ἡ μὲν κάθετος ἐμπίπτει ἐπὶ τὸ μεταξὺ τῶν δύο ἰρίδων, ἐπὶ τὸ τῶν μεταξὺ δύο φοινικῶν περιφερειῶν, ἔνθα οὐδὲν ὅλως ἀπατηλὸν φαίνεται χρῶμα·

The commentaries by Alexander of Aphrodisias and Olympiodorus became the main reference point during the Renaissance, though they did not completely replace the contributions by medieval commentators on the *Meteorology*. Alessandro Piccolomini adopted an extreme position: in his "Tractatus de Iride", he declared all studies made by the *Latini* to be utterly useless. Piccolomini's work, which was structured as a mathematical treatise, tackled the question of how colors changed towards black in relation to increasing distance and weakening vision, as well as other questions.

Piccolomini indicated that the changing distance, weakening visual power, and reflection were the main causes of the changing colors and of their formation through different reflections of the visual rays towards the sun. This was the conclusion Alexander of Aphrodisias had already reached, but it was possible to go further and relate the formation of the colors of the rainbow to the angle of incidence of the visual rays in the cloud, as Olympiodorus had pointed out. In the external band of the first rainbow the angle of incidence was greater, and therefore the penetration and the *mixtio* of the visual ray with the darkness of water was less. However, while reflection alone could be sufficient to cause the altered perception of the color of the sun, it seemed that this could not happen with much greater angles of incidence, where the *mixtio* could not take place. By reducing the angle of incidence the penetration of the visual rays increased, and as a consequence the *mixtio* of the visual rays with the color of the small drops of water also increased. Thus red, green, and blue (violet) were formed. Blue (violet) was the last perceivable color because the visual rays nearest to the perpendicular, though they could most deeply penetrate and mix with the cloud, did not have a sufficient angle of incidence to cause the altered perception of the color of the sun. To cause the appearance of colors, the angles of incidence had to be between a maximum and a minimum inclination.[126]

It is obvious that if the change of the angle of incidence were the only cause of the appearance of colors, it would not be possible to explain the contrary order of their arrangement in the second rainbow. Another element ought to be considered, which through being changed would counteract the effect of the increasing angle of incidence: distance. In other words, red would continue to appear

[126] Piccolomini, "Tractatus de iride," 124: "Radius enim visualis, si nimis forti extiterit, tunc aut nubem penitus pertransit, sicut radius perpendicularis, aut valde penetrans, quamvis maxima fiat dicta permixtio, debiliter tamen valde refrangetur, cum propinquior sit ipsi perpendiculari, ac naturam ipsius nimis sapiat, et ex hoc coloris phantasiam non causabit. Atqui e contra si radius magis quam necesse sit distabit a perpendiculari, tunc quamvis ad maximum angulum refrangantur, tamen modica fiet talis permixtio quam diximus luminis cum nigro nubis, et propter hoc etiam coloris emphasim non produxerit. Necesse est igitur quod radius ipse, nec nimis accedat ad perpendicularem, nec etiam nimis elongetur ab ea. Nam ad coloris productionem, non solum requiritur sufficiens ac debita permixtio luminis cum nigro nubis quae ex sufficienti penetratione causatur, quod non nimis longe a perpendiculari contingit fieri, sed etiam requiritur quod sufficiens refractio fiat, ad sufficientem, scilicet angulum; adeo quod non in tantum penetret, quod ad nimis parvum angulum reflectatur."

up to the maximum value of the angle of incidence, but the increased distance would weaken the strength of the vision of this red, making it appear first green and then blue (violet).[127]

But how to explain the colorless space between the two red bands? For Piccolomini this was due to the juxtaposition of two red colors with very different intensities: the red of the first rainbow would be much stronger then the red of the second, which would cause a change of the color towards white in the space between the two colors. To explain this phenomenon in the formation of the color red, Piccolomini referred to a presumed diverse structure or constitution of the external part of the cloud in which the rainbow is formed: that part would be less dense and its little drops would be 'badly' placed.[128]

Frequent references to ancient commentators were also made by Francesco Vimercati in his *Commentaries on the Meteorologica*, which was the most important edition with commentary on Aristotle's work published in the 16th century. Telesio certainly knew it, as he used Vimercati's translation, with few changes, in the first chapters of his *De iride*.

In his commentary on the Aristotelian passage concerning the double rainbow, Vimercati pointed out the difficulty of explaining the contrary order of the arrangement of the colors; it seemed evident to him that, if one strictly followed the laws of optical science, the arrangement of the colors in the internal rainbow should also be inverted since the visual rays nearer the perpendicular are always stronger than those departing from it.[129] Olympiodorus's solution should be rejected since he placed the perpendicular visual ray in the space between the two red bands of the rainbows, whereas

[127] Ibid., 125: "Distantiam enim pro colore puniceo generando sufficiens est, quare inferior peripheria secundae iridis punicea est […]. Secunda vero peripheria, cum iam determinata ac proportionalis illa distantia defecerit, ex qua talis refractio fieri habet, ut color punicens generetur; tunc quidem cum refractio ex nimia distantia debilis iam fiat, (ex nimis longa enim et nimis brevi distantia, debilitatur refractio, ut diximus) fulgidum ipsum tendit magis ad nigrum, ac viridem colorem producet; et consequenter alurgum in extima peripheria secundum eadem rationem, extra quam peripheriam nullus amplius color apparet, propter elongationem partium nubis a debita distantia pro refractione sufficienti ad colorum generationem."

[128] Ibid., 124: "Cum igitur e regione Solis rorida nubes constiterit, atque id iridis phantasiam secundum stillas disposita fuerit, tunc quaedam determinata distantia est inter nubes et Solem, ac inter nubem et visum, secundum quam non solum luminis cum nigro nubis permixtio ac penetratio, sed etiam refractio sufficiens est, ad hoc quod fulgidum ipsum non multum ab albedine deficere videatur, adeo ut puniceus, color producatur. Et haec determinata distantia incipit in exteriori iridis peripheria, ac perdurat extra ipsam, usque ad aliquam nubis partem, quod totum intervallum ex sui natura puniceum apparere debet. Sed quoniam, ut superius explanavimus, quilibet color iuxta nigrum positum, albior videtur, iccirco cum puniceus hic color, qui in dicto intervallo est, iuxta partem illam nubis valde remotam, situs est, a qua propter hoc quod nimium distantia superexcedit, refractio nobilissima est […] propter hanc, inquam, iuxtappositionem albus apparet, et etiam in coloribus iridis quae ab ipsa Luna fit, est videre. Cum igitur nubes ipsa, in illa quidem parte ad quam intervallum dictum terminatur, non multum densa sit, et bene secundum stillas disposita, tunc quidem secunda fit iris."

[129] Vimercati, *In quatuor libros*, 332: "Nunc ea dubitatio diluatur, qua obiici contra Aristotelem solitum est, si ex aspectu validiori color puniceus, minus valido viridis et purpureus appareant, rationi consonum, imo vero necessarium esse, ut intimus ambitus puniceus, extimus purpureus vedeatur. Aspectus enim radios ab intimo ad Solem, quam ab extimo validiores referri; quandoquidem perpendiculari radio, qui ad centrum arcus fertur, sunt propiores, monstratumque sit a perspectivis radium perpendicularem validissimum esse, nec unquam reflecti aut frangi; eos autem, qui ab illo recedunt, quo minus abducuntur, validiores esse, quo magis, imbecilliores."

according to the last part of Aristotle's treatment of the question that ray fell in the centre of the cloud.[130]

What then was the cause of the appearance of the color, which was the farthest away from the bright sun, in the place of the strongest reflection? According to Vimercati, some authors thought that this inversion was only accidental, and essentially due to two obstructing factors: the narrow internal space and the greater density of the cloud in its central part than in the external one.[131] Other authors denied that these factors could solve the difficulty, since the greater density of the central part of the cloud would have suggested placing the color red in the internal band.[132] The observed order of the arrangement of the colors could be explained by the fact that the visual rays near the perpendicular would penetrate more deeply into the cloud and for that reason would absorb more darkness of the water,[133] whereas the mixture would gradually lessen along with the increasing distance from the perpendicular. Reflection would thus take place at different levels of depth, and the greater strength from the optical point of view would become a greater weakness of the preservation of color.

How to solve the difficulties raised by the commentators, and especially how to explain the colorless space between the two rainbows? To answer these questions, Vimercati also turned to Alexander of Aphrodisias, but unlike Piccolomini, he did not consider the geometrical aspects of the problem. Rather, he thought that one should not understand Alexander's argument as based on the distances of points from a reflecting surface**,** so that the statement "a reflection does not take place from just any point in a mirror" became "a reflection does not take place from just any part of the cloud in which the rainbow appears". As a consequence, between the two bands of red color there would be a discontinuity only because that part of the cloud was too far away.[134] This solution

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[130] Ibid., 333: "An huic dubitationi occorrendum est, illud tradendo, quod Olympiodorus, utriusque arcus colorum diversitatem assignans, ex Ammonio commemoravit, nempe radium perpendicularem ad illud spatium ferri, quod inter utrunque arcum positum est. Illud itaque spatium, quod radio valentiori conspicitur, absque errore ullo a nobis apprehendi, tum id, quod sequitur, puniceum, qui color a Solis colore minus quam caeteri recedit, utpote minori errore conspectus. An prorsus falsum est, radium perpendicularem ad spatium id ferri, quandoquidem (ut post docebitur) ad nubis centrum fertur."

[131] Ibid.: "Hanc igitur dibitationem aliqui aliter sustulerunt, concedentes, per se quidem colorem, qui ad candidum magis accedit, in intimo ambitu apparere debuisse, ob eamque causam puniceum, nigriorem autem veluti purpureum in extimo, ex accidenti tamen ob duo impedimenta, candidiorem, qui est puniceus in extimo, et purpureum in intimo apparuisse; ac impedimenta quidem esse ambitus illius interioris parvitatem, atque nubis, in qua apparet, crassitiem et densitatem, quae longe maior est, quam in exteriori. His ergo duabus de causis Solis colorem in interiori ambitu minus perfecte repraesentari."

[132] Ibid.: "Sed si ex radiis validioribus, quales sunt, qui iuxta perpendicularem habentur, color Solis in nube perfectius apparere per se debeat, illis profecto impedimentis non tolletur, quo minus appareat; nam et a nube densiori magis reflectentur, utpote eam minus penetrantes…"

[133] Ibid.: "An vero potius dicendum est, radios perpendiculari proximos, quoniam caeteris validiores sunt, debiliter admodum, et ad angulos parvos reflecti, imo vero ipsam nubem magis penetrare, illique magis admisceri, ob eamque causam Solis colorem debiliter valde repraesentare, ac quo magis a perpendiculari recedunt, eo debiliores esse, validiusque et ad angulos maiores referri, ideo colores ad candidum propius accedentes, et a nubis nigredine remotiores ostendere."

[134] Ibid., 333, 338: "An vero, inquit ille [Alexander], non ab omni nubis parte aspectus ad Solem, aut lumen Solis ad aspectum reflectitur, sed reflexionem loca definita sunt et certa, definitamque et certam splendidi lumen mittentis corporis a speculo distantiam esse oportet? Ab his igitur speculis ita distantibus, situmque certum habentibus, arcum et colores repraesentari. Quibus in verbis videtur Alexander docere, ideo colorem nullum inter utrunque arcum apparere, quia nulla ibi reflexio ad Solem seu ad aspectum efficiatur […] Neque enim haec (ut mihi videtur) est Alexandri (quemadmodum

supported the explanation that the second rainbow was nothing else than an image of the first. This explanation, however, raised the essential difficulty of the mirror image's turning over from concave to convex.

Vimercati's work offered an overview of past opinions but the challenge of finding the true cause of this complex natural phenomenon was still open. This challenge was taken up by Bernardino Telesio.

4. Telesio's De iride

If we now analyzeTelesio's *De iride* we must first point out that it removes an ambiguity which was always present in the Aristotelian tradition. In the *Meteorologica*, Aristotle had accepted the theory of the visual rays issuing from the eye, giving up his own theory of vision. Alexander of Aphrodisias had tried to justify this way of proceeding, pointing out that from the point of view of the geometrical explanation of optical phenomena it was a matter of indifference whether vision took place through a visual ray issuing from the eye travelling towards the object that was seen or whether the eye passively received it from outside.[135] Medieval optical science had rejected this ancient theory, and Telesio accepted the general opinion on this point.

However, this seems to be the only time that Telesio followed the tradition of geometrical optics. In fact, in his critical discussion of the Aristotelian conception he rejects the fundamental assumption which explained the cause of the rainbow by means of optics, i.e. the assumption that the observer must be placed in the middle of the straight line joining the sun and the center of the mirror consisting of a great amount of small drops forming a cloud. To reject this assumption Telesio resorted to the same examples mentioned by Aristotle himself. In the case of the rainbow, which can be seen in the

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nonnulli crediderunt) sententia, sed quod in spatio illo nubes nimis distet; siquidem ait, certam luminosi corporis et speculi distantiam esse oportere, et ab his speculis, quae ita distant, reflexionem fieri; quasi dicere vellet, ab hac nube media non fieri, quoniam longius distet, quam ut possit reflectere. Nec vero ait Alexander, ab omni puncto speculi cuiusvis reflexionem non fieri, ut quidam putarunt, sed ab omni nubis, in qua arcus apparet, parte."

[135] Alexander of Aphrodisias*, In quatuor libros meteorologicorum*, 72*:* "Quoniam vero, quantum ad praesentem rationem attinet, nihil refert sive dicatur, quod visus ipse ad speculum ad aequales angulos refractus, in rem visibilem incidens, cum sub huiusmodi refractione res ipsa contigerit, illam videat; an dicatur potius quod res ipsa quae videri habet, propter aliqualem habitudinem, vel situm ad speculum per intermedium diaphanum patiens quidem atque affectum, emphasim faciat in speculo, quod quidem taliter diaphanum existat, ut non solum a colori pati possit, adeo ut alteri diaphano acceptam qualitatem elargiri valeat, verumetiam et conservare, propter politiem ac splendorem, emphasim possit; ita quod ab ipso dehinc tanquam ab aliquo colorato patiatur rursus atque efficiatur diaphanum ipsum quod intermedium est. Quoniam, inquam, nihil refert in praesenti negotio, sive hoc dicatur sive illud, opinionem sequitur modo, quae emissionem radiorum ponit, quam quidem mathematici approbant." *CAG*, 3,2, 151, 20–30: ἐπεὶ δὲ οὐδὲν ὅσον ἐπὶ τῷ λόγῳ διαφέρει ἢ τὴν ὄψιν λέγειν ἀπὸ τοῦ κατόπτρου ἀνακλωμένην πρὸς ἴσας γωνίας, ὅταν ὑπὸ τὴν τοιαύτην ἀνάκλασιν τύχῃ τὸ ὁρατὸν ὄν, προσπίπτουσαν αὐτῷ ὁρᾶν αὐτό, ἢ αὐτὸ τὸ ὁρατὸν διὰ τὴν ποιὰν σχέσιν πρὸς τὸ κάτοπτρον διὰ τοῦ μεταξὺ διαφανοῦς πάσχοντος ἐμφαινόμενον ἐν ἐκείνῳ, ὄντι τοιούτῳ [διαφανεῖ], ὡς μὴ μόνον πάσχειν ὑπὸ τοῦ χρώματος δύνασθαι οὕτως, ὡς διαδιδόναι τὴν ἀπ' αὐτοῦ ποιότητα ἄλλῳ διαφανεῖ, ἀλλὰ καὶ φυλάσσειν δυναμένῳ τὴν ἔμφασιν διὰ λειότητά τε καὶ στιλπνότητα, ὡς ἀπ' αὐτοῦ πάλιν τὸ μεταξὺ αὐτοῦ τε καὶ τῆς ὄψεως διαφανὲς πάσχειν ὡς ἀπὸ κεχρωσμένου, τῇ δόξῃ τῇ τῶν ἀκτίνων καθωμιλημένῃ τε οὔσῃ καὶ τοῖς μαθηματικοῖς ἀρεσκούσῃ προσχρῆται.

water drops raised by oars when rowing or in the drops splashed by hand, the former assumption is not verified. The same must be said for the rainbow which, in some particular conditions, is formed around the flame of an oil lamp. If we then add the experiences made with a transparent prism of glass to the examples mentioned by Aristotle a different explanation will obviously be needed.[136]

In Telesio's view, the rainbow should be explained on the basis of the assumption that light travels from the sun to the clouds and subsequently shines towards the eye. Light spreads from its source in all directions. In thin bodies such as air, it permeates them and can be perceived even when its source is not directly visible; in dense bodies, smooth and shining, light becomes more intense and while it doesn't penetrate them it is very bright and its color is not altered.[137] However, that does not happen when the light goes through something colored, or when, by illuminating a body with a certain density and depth, the light permeates it in a variable manner, making it shine with different colors. This was the case with water and with the clouds, which changed color from their natural whiteness to an increasingly greater darkness according to their greater depth or density. The cause of this alteration was the black color of matter, which became more notable when depth and density were more considerable.[138]

One also had to take into account the direction of the light, which could be either perpendicular or inclined. In the former case, light, reflecting on itself and acquiring strength, would have managed to

[136] Telesio, *De iride*, chap. 8, 5v-6r: "Quod igitur dictum est, vel eo una reflexione iridem fieri statuens Aristoteles, quod ibi modo fiat, ubi solum speculum sit nubes, et aspectum nostrum reflectere potest, probandus omnino videdur, minime vero e Solis illam regione tantum constitui decernes, oportere itaque aspectum nostrum medium inter Solem, nubemque fieri, et in eadem omnino linea Solem, aspectumque nostrum et iridis centrum polumque esse; passim enim irides intueri licet, quas inter, Solemque medii nos minime sumus […] et quae ex aqua Soli exposita, vel e guttis a remis sublatis, aut manu sparsis fiunt, nequaquam nobis inter eas, Solemque mediis fiunt, nec quae e serratili spectantur vitro, multoque etiam minus, quae circa lucernam fiunt."

[137] At the beginning of chap. 16 of *De iride*, Telesio refers to his *De rerum natura*. Here in book 4, chap. 10, 145 we read: "Itaque et ubi nullus conspicitur Sol, quo scilicet recta, qua sola progredi lux videtur, deferri non potest, a crasso quopiam retardata, reiectaque, et Sole non dum exorto, et penitus iam abdito, aliquantis per tamen universo in aere, et imis etiam in terris si non fulgida, at bene certe visilis, beneque spectatur clara. Non quidem id accidat nisi ab aere etiam, a se ipsa nimirum, vel summe exili in eo facta, reluceat. Nam quae a densis, aequabilibusque, et nitidis refulget rebus, a quibus, quod nihil eas subeat, integra relucet, et continua amplius, unitaque, nihil ab earum tumoribus, nec a maculis etiam […] intercepta, intercisaque ullis, nihilo, quam a Sole ipso minus fulgida, minusque relucet ingens. […] Nihil imminuitur ab ullo, quin in singulis bene in se ipsam colligitur, proindeque veluti alter Sol facta, a singulis, veluti a Sole ipso effulget, seseque effundit." For a *general* account of Telesio's light theory, see Mulsow, *Frühneuzeitliche Selbsterhaltung*, 104–139.

[138] Telesio, *De iride*, chap. 16, 14v–15r: "Et aquas, nubesque permeans, et relucens etiam ab iis, si paulo profundiores, densioresve sint, non albo amplius, qualis, et lucis, et illarum utriusque est color, sed longe pluribus, et omnibus propemodum, qui album, nigrumque intermedii sunt, et ipso etiam nigro colorata relucet, quod nimirum penitus eas subiens, earum materiae nigredinem attingit, et prout maiori, minorive eius portioni immiscetur, eo magis, minusve ab ea exuperatur, ad nigrumque agitur. Itaque ubi humile est mare, album, ubi paulo viride, et ceraleum ubi amplius, et nigrum ubi profundissimum, eo scilicet magis obscurata, ad nigumque acta, quae ab eo relucet lux, quo ampliori ipsius materiae nigredine immista est."

overcome the black structure of matter, whereas in the latter case it would have mixed with matter more and more deeply, becoming altered into different colors.[139]

Hence, the question of the rainbow shifted from a discussion concerning the problem of the formation of images in small mirrors to an analysis of the variation of light in more or less dense bodies.

When the sunlight reached the cloud suitable for showing the rainbow by the shortest line, its strength would have prevented it from undergoing any alteration; thereby it was seen without any particular color. With increased inclination, the light would have been increasingly affected by the darkness of the cloud and would subsequently have formed the red, green, and blue (violet) bands. After the formation of this last color the inclination of the light would have increased too much and its variation would have been too faint to be perceived.[140]

Once more the inclination would reach a maximum value and a minimum value, but this time it did not depend on the theory of reflection but rather on a somewhat original idea of the emanation of light from the body of the sun.

Although Telesio acknowledged it was a fact that each part of the things that were lit up received light from every point of the surface of the sun, he thought it possible to establish a special relationship between some parts of the cloud and some parts of its surface. The single parts of the cloud would have only shown that alteration of light which was predominant over the other, and that predominance would have depended on the way in which illumination was taking place according to the greater or lesser inclination. Thus Telesio could spot those parts on the surface of the sun which were, in his opinion, mostly responsible for such variation. These parts show two extensive bands symmetrically placed in the two hemispheres. According to him, it is not the whole surface of the sun that spreads the light that causes the rainbow. The outermost parts do not, since the inclination of the light's rays coming from them is too great, and even the central part does not since the light from it reaches the cloud by the shortest line.[141] Through this division of the surface of the sun, Telesio could treat the problem of the double rainbow with great surety.[142]

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[139] Ibid., chap. 16, 15r: "Itaque aquam in vitro contentam matutina, vespertinaque lux, quae scilicet, quod bene obliqua advenit, nihil reflexa inseipsam colligitur. Itaque ab inexistente aquae nigredine esuperata irinis coloribus intingitur omnibus, minime vero et meridiana, quae nimirum bene directa inseipsam reflectitur, proinde copiosa, robustaque facta, materiae nigredinem penitus esuperat."

[140] Ibid., chap. 17, 15*v*: "In nube omnino bene in se ipsam conspissatam, et a luce iridem fieri existimare licet, nec maxime directa, meximeque robusta, nec maxime obliqua, languidaque, sed ab ea quae harum quasi media sit […]."

[141] Ibid., chap. 17, 15*v*: "et ab ea forte, quae nequaquam a Solis parte emanet, quae nubi proximior, earumque, quae nubi expositae sunt, media est omnium; eam enim nubi directam imminere existimare licet; neque ab iis, quae maxime ab illa absunt, maximeque obliquam ad nubem emittunt lucem, sed ab iis, quae utrarumque veluti mediae sunt. Sphericus enim cum sit Sol, assidueque eius superficies immutatur, singulae eius partes proprium ad nubium partes quasvis situm obtineant oportet, eoque singulas a reliquis magis diversarum, quo magis ab iis absunt, obtineant oportet."

[142] Ibid., chap. 9, 8v-9v, Telesio had exactly noticed the contradiction in the passage where Aristotle had tied to explain the inversion of the arrangement of colors in the double rainbow. He had also carefully considered the solution of the problem offered in Olympiodorus' passage and had shown that it was untenable by briefly referring to the theories *perspectivorum*. Those explanations were similarly to be reject which had been offered by more recent commentators of the

The illumination coming from the central part explained the missing color between the red bands of the two rainbows, whereas these last two were the result of illumination by those parts of the extensive symmetrical bands nearer the central zone. This was in fact the light which was striking the cloud in a less inclined way. The more it travelled towards the outermost part of the extensive bands, the inclination of the light increased, and thus in the corresponding part of the cloud the green color appeared first and then the blue (violet) color.[143]

To summarize, the lower hemisphere—the one turned towards the surface of the earth—was responsible for the appearance of the internal rainbow, whereas the other hemisphere was responsible for the external rainbow.

The problem which had so strained the minds of the Aristotelian commentators seemed finally to have been resolved, although the premise on which the solution was based was far from sound. Telesio's attempt, however, remained outside the scientific tradition, since this tradition continued to refer mainly to the laws of geometrical optics until it finally found the essential precondition for any further research into the law of refraction.

5. Concluding remarks

In this essay I have read Telesio's *De iride* in connection with a scholarly tradition that can be traced back to Aristotle's *Meteorologica* (Book 3) and other sources of the Aristotelian corpus dealing with the formation of colors (*De anima* and *De sensu et sensibilibus*). As I have endeavored to show, Telesio's attempt to provide an adequate explanation of the phenomenon of the rainbow still operates within an essentially Aristotelian framework. Aristotle's treatment of the rainbow is particularly interesting as a case in which mathematical disciplines such as optics can help to comprehend the phenomenon. However, at the same time, mathematics is incapable of adequately accounting for one of the essential features of the phenomenon, namely its color. In spite of Telesio's disavowal of Aristotle, he cannot be placed outside the Aristotelian tradition of scholars and their explanation of the rainbow and its colors. Within this tradition I paid particular attention to Alexander of Aphrodisias

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Meteorologica, who "ab antiquioribus acceperant acquiescere impotentes, dictarumque diversitatum rationem reddere disperantes, si quomodo Aristoteli placet, iris utraque aspectus ad Solem reflexione fiat exteriorem minime eo pacto exoriri contendunt, sed interioris iridis imaginem esse". This last criticism seems to be directed to Vimercati.

[143] Telesio, *De iride*, chap. 18, 16r–16v: "A luce porro, quam diximus iridem fieri, non ratio tantum, sed eius colorum ordo aperte quidem in simplici, at multo etiam in duplici amplius manifestat. Propterea enim ubi duplex fit iris, non altera alteri contigua fit, proximaque, sed spatium inter utramque album spectatur. […]. Utraque nimirum iris, prout ab albo spatio magis recedit, magis ad nigrum, obscurumque, et aeque utraque, eodem que tendit modo, in eo tantum ab altera differens altera, quod superioris colores paulo, languidiores apparent, quod iris utraque, et quod utriusque medium est spatium ab universo quidem Sole, at non ab universo simul singuli iridis utriusque ambitus, intermediumque spatium, sed et hoc, et singuli illi a certa illustrantur Solis parte, et inter medium quidem spatium a media iridum ambitus, pro ut ab albo spatio magis recedunt, ita a Soli partibus, quae a media magis absunt; et interior quidem iris a Solis parte, quae infra eam, exterior vero ab ea, quae supra mediam est, illustrari videtur."

and Olympiodorus. Although Telesio breaks with the extromissive theory of visual rays put forward by ancient writers on optics, this does not radically alter the framework of his explanation: in fact, this break would seem to bring him even closer to a genuinely Aristotelian theory of vision.

The instance of the double rainbow is a crucial example. The Aristotelian solution de facto entails taking two separate mathematical components into consideration: on the one hand, in relation to the internal rainbow, the magnitude of the arches of the various colors; on the other, in relation to the external rainbow, the observer's distance from the reflecting surface formed by suspended droplets. Ancient and Renaissance commentators, including Telesio, tried to reunite these two mathematical components by employing geometrical analysis and a theory of perception. Further, they addressed the related question of why the space between the two rainbows is colorless.

In my view, it is only through such contextualization that we can understand Telesio's *De iride*. Telesio's theory of the formation of colors, which is so closely linked to the idea of matter, does not greatly differ from some of the solutions proposed in previous centuries, for instance by Olympiodorus. The alteration of the color of natural light depends on the density and depth of the illumined body. The cause of this alteration is the blackness of matter, which only becomes perceivable when this depth and density is substantial. It can hardly be denied that, given these assumptions, the appearance of a rainbow no longer has to do with the problem of the formation of images in tiny mirrors, but rather becomes a problem related to the variation of light in bodies of varying density. Although these ideas point beyond the Aristotelian conception, Telesio does not take the actual step taken by later writers on optics. He does not argue for the refraction of light rays as one of the causes of the formation of colors. While Telesio thought that the variation of the obliqueness of these rays plays a crucial role in the appearance of the colors of the rainbow, this element is never further explored through an in-depth study of optics.

This observation provides us with an improved appreciation of the importance of the work of other Renaissance scholars for Telesio, among whom are Alessandro Piccolomini and Francesco Vimercati. Piccolomini translated Alexander of Aphrodisias' commentary on the *Meteorologica* and was the author of a *Tractatus de iride*, which are fundamental sources for Telesio's treatment of the rainbow. Far more relevant for the study of Telesio's views is Francesco Vimercati's *Commentaries on the Meteorologica*, which was the most important commented edition of Aristotle's work to have been published in the second half of the 16th century. In this text he reopened the discussion on the phenomenon of the double rainbow.

Telesio derived his discussion of the double rainbow from these sources, and not from any mathematical enquiry—less still from any experimental study. Once he was aware of the fact that it is impossible to come up with a convincing interpretation of the phenomenon within a strictly Aristotelian framework, Telesio departs from it and develops a new explanation. Telesio proceeded

using a process of ‘elimination’ of all those elements which inevitably led to unsolvable contradictions. Although this resulted in a very different interpretation of the phenomenon than Aristotle’s, it nevertheless directly derived from it. Telesio’s *De Iride* is representative of the wider context of the Renaissance debates about the reception, transformation or refutation of Aristotelian themes.

12.

The Transformation of Final Causation: Telesio's Theories of Self-Preservation and Motion

Rodolfo Garau

In an attempt to overcome the widespread narratives concerning Telesio as a precursor of Newton (Cassirer) or as a prisoner of an unscientific form of hylozoism (Gentile),[144] current scholarship has increasingly emphasized the anti-Aristotelian traits of Telesio's philosophy as his most historically relevant contribution to the development of early modern natural philosophy. In a paper tellingly entitled *The First of the Moderns or the Last of the Ancients?*, Guido Giglioni argued that the notion of sentience, far from representing an outmoded vestige of a naive animism, provided the basis for a radical shift from the Aristotelian notion of movement, and thus must be seen as the most original trait of Telesio's natural philosophy. Giglioni writes,

> […] the Aristotelian notion of nature suffered from an ineliminable residue of Platonism, in that all natural beings, in their irresistible tendency to be actualized by the form, appeared to be drawn to a principle that in the end transcended nature itself, regardless of whether that principle was the unmoveable mover, the pure actuality of the ultimate form or the active intellect. Put in a nutshell, the actions of nature were supposed to terminate in something other than nature itself.[145]

Detaching himself from the fundamental kernel of Aristotelian natural philosophy, Telesio saw the Aristotelian notion of nature as an insufferable deviation from his project of understanding nature *iuxta propria principia*. While he did not reject the project of understanding nature within a teleological framework or declare teleology as present but unintelligible (as many seventeenth-century inquirers would do), Telesio rejected the idea that the *telos* was somehow situated outside of nature. As Giglioni observes,

> [Telesio first] dismissed the notion of nature as an unconscious source of activity by emphasizing instead its fully sentient character; second, he demonstrated that the view of unintentional finalism was a pure abstraction of the intellect, for nature could not be regarded as occupying an autonomous sphere of activity without adding the decisive qualification that it has to be aware of its ends and purposes.[146]

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[144] See Cassirer, *Das Erkenntnisproblem*, Gentile, *Bernardino Telesio*, in *Opere complete di Giovanni Gentile*, 133–206.
[145] Giglioni, "The First of the Moderns or the Last of the Ancients?," 85.
[146] Ibid.

The reaction of Telesio's contemporaries to the publication of *De rerum natura* seems to confirm that what struck its readers was the proposal of a system of natural philosophy that represented a coherent and all-encompassing alternative to Aristotelianism.[147] Its novelty was not necessarily seen in the alternative physical theses propounded by Telesio but rather in its ambitious attempt to replace the very fundaments of Aristotelianism. In 1572, the Platonic philosopher Francesco Patrizi was asked to draft some of his major objections to Telesio's theories. On that occasion he was certainly not very lenient with Telesio's work. Patrizi accused Telesio of reviving the vision of nature of the pre-Socratic philosopher Parmenides. Second, Patrizi observed that Telesio largely based his theories on abstract reasoning (excluding his well-known claim that all true knowledge either derives from sensation or is developed by means of an analogy with sensory experience). According to Patrizi, Telesio's scarce reference to direct observation is also exemplified in glaringly counterfactual claims, such as the claim that heat cannot derive from motion but, vice versa, that heat always precedes motion as a substance precedes its operation. On the contrary, the most coherent aspect of *De rerum natura* seemed to Patrizi to be the second book, devoted to the confutation of concurrent Aristotelian theories—therefore the *pars destruens* more than the *pars costruens* of Telesio's system. Patrizi described this part of *De rerum natura* as "greatly worthy of admiration".[148] Similarly, a few years later, the Italian philosopher Tommaso Campanella would seek in Telesio's *De rerum natura* a source to elaborate an alternative to Scholasticism.[149]

Framing Telesio's thinking in the context of the (pre-?)modern polemics against Aristotelianism surely provides a more historically sound understanding of his works. Developing the image of Telesio as "first of the moderns", to use Bacon's phrase, scholars have sometimes popularized him as a forerunner of Newton, an advocate of sensory knowledge, a denier of the authority of Aristotle, and a critic of the esotericism of contemporary magical and hermetic knowledge (Cassirer is one example). At other times, they have instead deemed his reference to animism and universal sensibility a vestige of magical and pre-scientific thought (e.g. Gentile).[150] Against these narratives, projecting Telesio's work against the background of Aristotelianism represents a more insightful way to represent his work. At the same time, however, this makes the evaluation of Telesio's influence on early modern thought (and in particular on the development of seventeenth-century proto-inertial natural philosophy) more problematic. While scholars have shown that his work influenced major seventeenth-century intellectuals such as Bacon, Descartes, Gassendi, and Hobbes,[151] at the same time

[147] On this, see also Omodeo's introduction to this volume. Bondì provides a very good discussion of Telesio's influence in Bondi, *Introduzione a Telesio*.
[148] See Fiorentino, *Bernardino Telesio*, 375–98.
[149] See Badaloni, *Tommaso Campanella*.
[150] Cassirer, *Das Erkenntnisproblem*; Gentile, *Opere complete*, 133–206.
[151] See for instance Bondì, *Introduzione a Telesio*; Schuhmann, "Hobbes and Renaissance Philosophy;" Mulsow, *Frühneuzeitliche Selbsterhaltung*.

these authors (with the notable exception of Bacon) rarely referred directly to Telesio in their works, and almost never mentioned him as a source of their theories. Therefore, the problem of how to treat the relationship between Telesio and seventeenth-century natural philosophy seems to be an almost insurmountable methodological riddle.

This paper focuses on a notion closely connected to that of sentience, one which was indicated by Giglioni as the most original trait of Telesio's philosophy—self-preservation. In *De rerum natura iuxta propria principia*, Telesio argued for the existence of two antithetical active principles, heat and cold, which correspond to the sun and heaven and to the earth respectively, and yield motion, change, rest, and immutability. Heat and cold, rather than actively producing the matter on which they act, are the principles of its change, while the "mass or body" (*moles vero corpus*) on which the two active natures act remains, although its nature and form changes (I, 5, 17).[152] Telesio attributed a crucial role to self-preservation, arguing that both principles are essentially antithetical and tend to counteract each other and seek their own preservation.

The aim of this paper is not to offer a genealogical reconstruction of Telesio's notion of self-preservation (as Martin Muslow has already remarkably done),[153] but rather to analyze this concept and its use within Telesio's natural philosophy with special regard to Telesio's doctrine of motion. While here I intend to provide a *working hypothesis* rather than a solid *Wirkungsgeschichte* (because, as I have mentioned, a study of Telesio's influence on early modern culture is made difficult by a patent scarcity of sources), I suggest that this doctrine likely had a lasting influence on seventeenth-century developments of natural philosophy. I argue that Telesio's notion of self-preservation represents not only another element of critique of Aristotelianism but also a crucial turn in the way Scholastic physics understood activity in nature. Second, I show that Telesio's notion of self-preservation was likely motivated by the need to provide an alternative to the Aristotelian theory of motion, and in particular was rooted in some crucial inconsistencies in Aristotle's theory of falling objects. In the conclusion of my paper, I hint at some possible bearing of Telesio's doctrine of self-preservation on early modern proto-inertial natural philosophy, in particular on authors such as Descartes and Spinoza. While it is not possible to establish that Telesio's natural philosophy directly influenced these

[152] Latin quotations are taken from Telesio, *La natura secondo i suoi principi* (2009).

[153] In a book devoted to Telesio's notion of self-preservation, Martin Muslow (*Frühneuzeitliche Selbsterhaltung*) cautioned against viewing Telesio through the later narratives of the "Parmenidean sect" and of the revival of Stoic thought, which would put Telesio in direct connection with Vives and Spinoza. In contrast, he demonstrated a profound connection between Telesio's notion of self-preservation and the medical, astronomical and optical discussions of the time, the diachronic transformations of Aristotelianism and Galenism, as well as the Avicennian and Averroistic influence in sixteenth-century Padua, where Telesio was educated. See Muslow, *Frühneuzeitliche Selbsterhaltung*, 397: "Die Phasen, die sich als Schwellenzeiten in der Entwicklung des Begriffs der conservado sui herausgestellt haben, mußten erst gegen die Blockade von Mythen der Rezeptionsgeschichte freigelegt werden. Die grands récits, die durch vorschnelle Vereindeutigungen der Positioniserung Telesios die faktischen Verhältnisse verdunkelt haben, sind im 17. und 18. Jahrhundert die Fabel von der Wiederbelebung der parmenideischen Sekte durch Telesio und im 19. Jahrhundert die Vorstellung einer frühneuzeitlichen natürlichen Geisteswissenschaft aufgrund einer durchgängigen Stoa-Rezeption von Vives bis Spinoza gewesen."

authors, and despite rejecting the narratives of Telesio as a "forerunner" or "anticipator" of modern mechanism, I argue that Telesio's critique of the Aristotelian doctrine of motion and activity, and its explanation in terms of self-preserving tendencies, likely contributed to the creation of the intellectual atmosphere from which early modern mechanism stemmed.

This paper is divided into four sections. First I offer a short reconstruction of the theme of self-preservation in Western philosophy, focusing in particular on its reception within Scholasticism. Second, I reconstruct Telesio's notion of self-preservation. Third, through a comparison with the Scholastic (and even pre-Scholastic) notion of self-preservation, I show that Telesio's detachment from the Scholastic tradition consisted of three traits: (1) the claim that this tendency to self-preservation is teleologically oriented but not intrinsically definite in time (i.e. does not have a *terminus ad quem*); (2) that while the Thomists grounded the drive to self-preservation within a structured theological framework (in which the instinct to self-preservation stems from the love of God for his creation), Telesio's project of a study of nature "within its own principles" excludes such a theological structure; (3) this solution brings about a decisive shift from a teleology conceived as the passage between different states and having goals extrinsic to the subject to one that I will define as "autotelic", in which the subject itself (its persistence in existence and increase in power) becomes the goal of activity. Fourth, I show how the notion of self-preservation helps to provide (and was likely motivated by the search for) an alternative explanation to Aristotle's theory of motion, which was rooted in the dualism between natural and violent motion. In Telesio's mind, self-preservation replaces the idea that the tendency to motion is brought about by the form of things. This conclusion is admittedly the most hypothetical part of my paper. Indeed, the autotelic drive to self-preservation characterizes many (proto-)inertial natural philosophies of the seventeenth century, such as those of Descartes and Spinoza. While it is uncertain to what extent Telesio's philosophy influenced these authors, I argue that Telesio's notion of self-preservation helped to create the intellectual atmosphere that led to further development of seventeenth-century mechanism.

1. The concept of self-preservation: an ancient legacy

The idea that living entities, and all things in general, tend to act in a self-preserving fashion is likely one of the most widespread ideas in the history of Western thought. One of the main points of contention between the Stoics and Epicureans consisted precisely in establishing the nature of what they called *hormé*, i.e. the first (or fundamental) action of living entities or their natural inclination to action. Stoics claimed that *hormé* was addressed to self-preservation (which in turn they believed was accomplished through the unfolding and realization of the animal essence, a process they termed *oikeiosis*) and resulted from the providential action of an immanent God, while the Epicureans (who

denied divine providence by stating that the universe originated by chance) believed that it was addressed to the search for pleasure and the avoidance of pain. This debate was recorded by many ancient 'historians of philosophy', as for instance Diogenes Laërtius:

> […] an animal's first impulse [πρώτην ὁρμήν], say the Stoics, is to self-preservation, because nature from the outset endears it to itself, as Chrysippus affirms in the first book of his work *On Ends*: his words are, 'The dearest thing to every animal is its own constitution and its consciousness thereof';[...] We are forced to conclude then that nature in constituting the animal made it near and dear to itself; for so it comes to repel all that is injurious and give free access to all that is serviceable or akin to it. As for the assertion made by some people that pleasure is the object to which the first impulse of animals is directed, it is shown by the Stoics to be false. For pleasure, if it is really felt, they declare to be a by-product, which never comes until nature by itself has sought and found the means suitable to the animal's existence or constitution[154] […].

Animals, as much as men, appear to be endowed with a natural instinct to know what is harmful and what is helpful to them. Their actions in the world, despite not being determined by ratiocination, seem to be motivated by a fundamental instinct to survive and by an innate knowledge of what could be useful to this aim. The Stoics seem to have believed that such an instinct revealed the providential action of nature. For instance, Cicero noted that "Nature has provided with bounteous plenty for each species of animal that food which is suited to it […]. But nature has also bestowed upon the beasts both sensation and desire, the one to arouse in them the impulse to appropriate their natural food [*conatum haberent ad naturales pastus capessendos*], the other to enable them to distinguish things harmful from things wholesome"(II, XLVIII).[155]

Wolfson, the great historian of ideas,[156] claimed that the Stoic idea of *hormé* was taken up by philosophers as diverse as Augustine,[157] Thomas Aquinas, and Dante Alighieri[158] in the Middle Ages. It is hard to establish whether this was a direct Stoic influence or a parallel development. Surely, the Christian conception of God as a loving and caring demiurge reinforced the connection between self-preservation and divine providence. Here, the Augustinian notion of "natural love"—the love all creatures have for the means that are useful to their preservation, caused by and reflecting God's providential love for his creation—assumes crucial importance. Aquinas claimed that the greatest example

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[154] Diogenes Laërtius, *Life of Eminent Philosophers*, 193.
[155] Cicero, *De natura deorum*, 239. See also ibid., 178: "[…] as the other natural substances are generated, reared and sustained each by its own seeds, so the world-nature experiences all those motions of the will, those impulses of conation and desire ("conatus et adpetitiones"), that the Greeks call hormae, and follows these up with the appropriate action in the same way as do we ourselves, who experience emotions and sensations" (II, 58).
[156] See Wolfson, *Philosophy of Spinoza*.
[157] Augustine, *City of God*, 537: "What of animals in general, even irrational animals that have no power to reflect on these things? Do they not, from huge serpents down to tiny little worms, what that they want to go on being and, in order to do so, seek to escape death by every movement at their command? What of trees and shrubs of every kind that have no sensation to enable them to avoid destruction by perceptible movement, yet do they not ensure the growth of their topmost germinal shoots into the air by fixing another growth, of root, into the ground so as to draw nourishment from it and so, in their own fashion, preserve their existence?" (XI, 27).
[158] Dante Alighieri, *Monarchy*, 20: "[…] everything that is desires its own being […]" (I, 13).

of this was that each and every thing had a natural appetite for its own preservation.[159] In the *Summa Theologiae*, using the Aristotelian idea of "practical good", he described this natural appetite for self-preservation as the love "with which each and every particular thing loves its own good because of the common good of the whole universe, that is God" (I-II, q. 109 a. 3 co.).[160] In another passage of *De veritate*, he quotes Boethius to link self-preservation to divine providence: "Everything that already exists loves its particular being naturally, and preserves it with all its strength; from which Boethius says in the third book of *De consolatione:* divine providence gave to the things it created such greatest cause of persisting, so that, insofar as they can, they naturally desire to persist" (Q. 21 a. 2 co.).[161] However, while animals cannot avoid this natural drive toward their practical good, humans represent a more peculiar case. While each and every human being possesses a "natural appetite" by virtue of which (s)he wants to "exist and live",[162] "the disposition of human actions to the end is not according to nature, as it is with the irrational creatures, that act towards the end according to natural appetite only, but man acts towards an end through reason and will. So there is no natural law for human beings" (*Summa Theologiae* I-II, q. 91 a. 2 arg. 2).[163] While eventually the rational and voluntary determination of actions also depends on the love for good itself (God), Aquinas here is describing man as an "empire within an empire" (to use Spinoza's famous expression), whose actions do not strictly comply to any law.

2. Telesio's notion of self-preservation

The passage from a teleology understood as tending to something beyond nature to one in which that something is reabsorbed within the domain of nature (described by Giglioni in the passage quoted in the introduction above) can be found, perhaps even more glaringly, in Telesio's notion of self-preservation. In Telesio's system, matter, per se neutral and amorphous, is dominated and continuously transformed by two principles: heat (having as its source the Sun and heaven and representing a principle of indefinite motion) and cold (having its place on the Earth and naturally deprived of

[159] Thomas Aquinas, *On the Power of God*, 79: "Everything has a natural appetence [appetitu naturali] for the preservation of its existence" (Q. 5, Art 1, 13).
[160] Thomas Aquinas, *Summa Theologiae*, electronic edition, http://www.corpusthomisticum.org/: "Manifestum est autem quod bonum partis est propter bonum totius. Unde etiam naturali appetitu vel amore unaquaeque res particularis amat bonum suum proprium propter bonum commune totius universi, quod est Deus."
[161] Thomas Aquinas, *De veritate*, electronic edition, http://www.corpusthomisticum.org/: "Omnia autem quae iam esse habent, illud esse suum naturaliter amant, et ipsum tota virtute conservant; unde Boetius dicit in III de consolatione: dedit divina providentia creatis a se rebus hanc vel maximam manendi causam, ut quoad possunt, naturaliter manere desiderent. [...]."
[162] Thomas Aquinas, *Summa Theologiae*, electronic edition, http://www.corpusthomisticum.org/: "Uno quidem modo, appetitu naturali**,** sicut omnes homines volunt esse et vivere" (II–II, q. 30 a. 1 co.).
[163] Ibid.: "…ordinatio humanorum actuum ad finem non est per naturam, sicut accidit in creaturis irrationabilibus, quae solo appetitu naturali agunt propter finem, sed agit homo propter finem per rationem et voluntatem. Ergo non est aliqua lex homini naturalis."

motion). Heat and cold, rather than actively producing the matter on which they act, are the principles of its change, while the "mass or body" (*moles vero corpus*)—on which the two active natures act—remains, although its nature and form change (I, 5).[164] The earth, and in particular its surface, is the battlefield of these two opposite principles, from which all things, both organic and inorganic, originate.

In this system, the notion of self-preservation assumes a particular value. Telesio gives the tendency to self-preservation a fundamental role in his natural philosophy by placing two mutually antagonistic active principles, heat and cold, at the core of his view of nature and by making an informed and passive substance, matter, the battleground between these two principles. The two principles cannot fade away in time, leaving behind them an uninformed matter. In this context, the tendency to self-preservation becomes the key element to explain the mutual action of the two principles. In other words, self-preservation represents their essential, antagonistic way of acting upon each other to inform matter. As Telesio writes,

> Since it never forgets its disposition, each active nature [*natura agens*] never desists from acting [*nunquam agere cessat*] but fights and repels even similar natures to expand in their places, desiring to the greatest extent to be equal to itself and to preserve itself [*talis esse servarique*], and to expand to a greater extent […] (I, 13)[165]

In this framework, justification for the presence of this sheer instinct to self-preservation is provided by the combination of several qualities. If natures are endowed with this drive to self-preservation, they must be endowed not only with an appetite for their own preservation (*conservationis appetitum*) and with hate of their own destruction (*propriae destructionis odium*) but also with a form of sensation, which Telesio describes as a "force" or "faculty" (*vim*) to recognize what is contrary and dissimilar to them and what can preserve or corrupt them. As he writes,

> […] *the faculty of feeling [*sentiendi facultatem*] was given to both active natures, and only in this do the earth and the sun resemble each other* […]. But if natures were to preserve themselves [*si servandae sint naturae*], not only was it necessary that they had a great desire to preserve themselves [*conservationis appetitum*] and a great hate of their own destruction [*propriae destructionis odium*] but also the faculty to recognize what is alike and similar and what is contrary and dissimilar [*cognata similiaque et contraria dissimiliaque dignoscendi vim*]. Indeed, they would not desire to preserve themselves [*conservari appetant*] nor they would fight corruption [*corrumpi aversentur*] if they could not recognize which things preserve and which corrupt them, and if they were not bound to the inclination to repel the former and to pursue the latter (I, 34).[166]

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[164] Telesio, *La natura secondo i suoi principi*, 16.

[165] "[…] qualiscunque enim existit natura agens quaevis nunquam proprii ingenii oblita nunquam agere cessat, sed vel similes cognatasque oppugnat deturbatque, ut in earum se ipsam sedibus amplificet qualiscunque est talis esse servarique et diffundi amplius atque in subiectis produci omnibus summe appetens summeque contendens. Quod igitur dictum est agentia rerum calor esse frigus videntur." (I, 13, 38).

[166] "*Sentiendi facultatem naturae agenti utrique traditam esse, et in ea sola Caelo Terram coonvenire* […]. Si servandae sunt naturae, non summum modo illis conservationis appetitum summumque propriae destructionis odium indi oportuit, sed cognata insuper similiaque et contraria dissimiliaque dignoscendi vim; frustra enim conservari appetant et corrumpi aversetur, nisi a quibus serventur et a quibus obleadantur disgnoscant, et fugiendi haec et sectandi illa studio teneantur" (Telesio, *La natura secondo i suoi principi*, 104).

Since matter is inert and not endowed per se with any quality, all sensation (even that of animals or human beings) must derive from the natures that inform matter. As Telesio claims, as heat and cold were given the feeling of their own preservation and destruction [*propriae conservationis et propriae destructionis sensus*], it is necessary that all beings are also endowed with them, i.e. that the active natures present in each body feel; indeed, what beings are, act, and undergo is due to the natures that constitute them, because matter per se lacks any knowledge of itself [*conservationis et proprii boni sensus*] (I, 34).

Rooted in the very essences of the two natures, sensation embraces the whole of nature, from inanimate to animate bodies. What is more, the sensation of superior beings is not a characteristic they possess exclusively but it is due to the action of the two principles. Nerves and sensory organs are only paths that channel the action of the principles rather than representing the faculty of sensation per se. On this basis, Telesio's account of self-preservation embraces animate beings as well as inanimate ones.[167]

3. Telesian self-preservation vs Scholastic self-preservation

The use of an "anthropomorphized" lexicon in the natural discourse was surely not exclusive to the Telesian account of natural phenomena. Rather, the idea that natural things possessed "appetites", "impulses", or "tendencies" can be commonly found in Scholastic treatises on natural philosophy. In *Summa contra Gentiles*, Aquinas describes as follows the tendency of the stone to descend:

> […] there is in every thing an appetite for good [*appetitus boni*]: for good is what every thing desires [*appetuntur*], as the philosophers teach. In this way, the appetite in things that lack thought is said to be a natural appetite, as for instance it is said that the stone desires [*appetit*] to be below. In things which have sensitive thought, it is said to be an animal appetite, which is divided into concupiscible and irascible. In things which have intelligence, it is said to be an intellectual or rational appetite, which is will (*Summa contra Gentiles*, II, 47, n. 2.).[168]

Even in the seventeenth century, Goclenius, in his *Lexicon Philosophicum*, distinguished three proper usages ["*naturalis appetitus*", "*animalis appetitus*" and "*appetitus*" of the "*naturae intelligentis & voluntariae*"]. Goclenius himself underlined the "ambiguous nature of the term", showing that an "appetite" is said to be "of fire to occupy the superior places, of iron to conjoin with the magnet, of plants to absorb the lymph, of horses to Venus [to pleasure], of men to beatitude". "*Naturalis appetitus*", an acceptation that Goclenius describes however as somewhat inappropriate ["…*qui dicitur quodammodo improprie appetitus*", "that is called somewhat inappropriately appetite"], applies both

[167] See for instance I, 35. Here, Telesio claims that all beings, also those that do not have sensory organs, possess sensibility.
[168] Alarcón, "Corpus Thomisticum", *www.corpusthomisticum.org*, 2000.

to "plants which attract toward themselves and desire aliments *without sensibility* ["… *in stirpe, quae attrahit & appetit alimentum absque sensu* […]" and to "inanimate things, such as the magnet ["*In inanimis, ut magnete*"]."[169]

The real novelty of the Telesian account of self-preservation consists in its lack of spatial and chronological determination, i.e. its lack of *telos* or *terminus ad quem*. In Scholastic philosophy, the preservative action of things was always identified with the achievement of the end that qualified the essence of the thing in question. As Aquinas epitomizes in his *Summa theologiae*, "…goodness is what all things desire [*appetunt*], that is, what they have as an end; it is clear that goodness is what is brought about in reason of the end."[170]

In contrast, in Telesio's picture of nature the search for "goodness", i.e. the search for the preservation and increase of the principles' essence, is an activity that is not restrained or confined in time and does not have a final conclusion—either temporal or spatial. While, say, the *appetitum boni* of the stone to reach its natural place is fulfilled (at least partially) once it touches ground, the appetite for preservation of Telesian principles characterizes their eternal, unrestrained activity. This marks a passage from a hetero-teleological picture of nature to an autotelic one, i.e. one in which the maintenance and increase of a thing's nature becomes the only way activity can be understood. As a consequence, the activity of a thing that does not suffer from the action of its contrary is potentially infinite:

> […] in order for a thing to be for eternity and in infinite time, and therefore operate according to its own nature in infinite time, there is no need to be incorporeal or infinite itself, or that it needs to be supported by such a thing. On the contrary [it is only necessary that], as little as the thing can be, it does not suffer from its contrary and it is not changed (DN1, II, 55).

Another fundamental novelty of Telesio's notion of self-preservation is its disconnection from the theological framework that, as we have seen, traditionally associated it to the notion of divine providence. To provide a further example of this connection between divine providence and self-preservation, we can quote Aquinas once again. In *De potentia*, answering the first article of the *Quaestio 5,* Aquinas asks whether "things are preserved in being by God, or, any action of God excluded, they persist in being by themselves."[171] A possible argument in favor of the latter option, Aquinas states, is that "…the natural appetite cannot be vain and false. But each natural thing naturally desires the preservation of its own being. Therefore a thing can be preserved through itself, otherwise natural

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[169] "Distinctio ambigae verbi naturae. Appetitus ὁμονύμω dicitur: In igne ad occupanda loca superiora:in ferro ad sui conjunctionem cum magnete: in planta ad humore sugendum: in equo ad Venerem: in homine ad beatitudinem", Goclenius, *Lexicon philosophicum*, 114. Similarly, Francesco Bonamici, in his *De Motu*, used the term '*appetitus*' and provided a general definition of it as the "inclination [*inclinatio*] which is necessary from the nature of every thing to agree to the good that convenes to itself according to nature." See Bonamici, *De Motu*, 28.

[170] "[…] bonum sit quod omnia appetunt**,** hoc autem habet rationem finis; manifestum est quod bonum rationem finis importat" (Aquinas, *Summa Theologiae* I, q. 5 a. 4 co.).

[171] *De potentia,* Q.5 Art.1: "[…] utrum res conserventur in esse a Deo, an etiam circumscripta omni Dei actione, per se in esse remaneant."

appetite is vain."[172] However (and this is Aquinas's position), things can well possess an appetite for their own preservation but have no power to preserve themselves in being: they are preserved in being by their cause – namely, by God. As he writes, "…it is admissible that every thing naturally desires its own preservation, though not that it is preserved by itself but by its cause."[173]

Through his notion of self-preservation and universal sensibility, Telesio completely overturns this perspective. As we have seen, in order to justify the fact that things act self-preservingly, "not only was it necessary that they had a great desire to preserve themselves [*conservationis appetitum*] and a great hate of their own destruction [*propriae destructionis odium*] but also the faculty to recognize what is alike and similar and what is contrary and dissimilar [*cognata similiaque et contraria dissimiliaque dignoscendi vim*]" (I, 34, Latin quoted above). In other words, the doctrine of universal sensibility, in addition to identifying the teleological tendency of things within nature and not without it (as Giglioni stressed), also provides a fundament to explain the self-preserving action of things outside a theological framework, or, to use Telesio's expression, according to the principles of nature alone. In this context, the reference to God (the only one in the whole second book of *De rerum natura*!) is just a reminder of the role of the author of nature, and it seems to be merely a justification ex-post of the order and harmony of nature. Although active natures fight for the affirmation of their being and reciprocally seek to destroy each other, there seems to be a sort of measure in nature, from which beautiful things stem in great number according to a certain order. Telesio explains that this is due to "God the perfect and greatest, not the oblique motion of the Sun; this motion itself is indeed to be understood as a work of God and certainly as produced with admirable wisdom."[174] Here, though, God is just the author of the world: he does not act as the final end of a thing's action, as in Aquinas. Again, the teleological tendencies of active principles, as well as nature in general, are to be found entirely within nature and not without.

4. Self-preservation vs natural and violent motion

How does this principle of self-preservation effectively come into play to explain natural phenomena? The most interesting application of the principle (and probably also the true motivation underlying Telesio's theory) is related to the explanation of the nature of motion, in particular as an objec-

[172] Ibid., Q.5 Art.1 arg. 13 "Praeterea, appetitus naturalis non potest esse cassus et vanus. Sed quaelibet res naturaliter conservationem sui esse appetit. Potest ergo res per se ipsam conservari in esse; alias appetitus naturalis esset vanus."
[173] Ibid., Q.5 Art.1 arg. 13 "Ad decimumtertium dicendum, quod licet quaelibet res naturaliter appetat sui conservationem, non tamen quod a se conservetur, sed a sua causa."
[174] "Neque igitur sese mutuo perdant aut imminuant omnino quid, et longe plurima constituant longeque pulcherrima, et eadem semper ratione omnia. Hiuiusmodi Deus ipse Optimus Maximus, non obliqua Solis latio videatur, quae eiusdem Dei videri debet opus, et admirabili quidem constituta sapientia" (II, 37, 344).

tion to Aristotle's theory of natural motion. As is well known, the vulgate of Aristotle's physics proposed by the Scholastics divided motion into two kinds: natural, i.e. motion caused by the form of the object and aimed rectilinearly at the center of the corresponding sphere; and violent, i.e. motion caused by an external force and directed not in the direction otherwise followed by the thing in question. In this context, what we now call "acceleration of gravity" was seen as proportional to the weight of the object in question (in turn determined by its form) and the density of the medium across which the object travels.[175] The notion of natural motion, in particular, is at the center of Telesio's criticism. Things, according to Telesio, cannot move and then rest. If movement pertains to a certain thing, it would continue indefinitely, and vice versa if a thing is at rest there is nothing in the thing itself that would make it move in a second moment. As the incipit of I, 43 recites,

> The Earth is absolutely contrary to heaven and no motion corresponds to it, and the arguments of Aristotle according to which he attributes to it and to all other bodies a natural motion are absurd [...][176]

As Telesio continues,

> One shall not think that things that appear by their own nature to lie down and to be immobile, though they have been seen to reach spontaneously that place, are carried there by their own natural motion; for immobility and motion cannot be of the same nature; instead, it is necessary that things that are by nature immobile are entirely devoid of any motion, and that, in contrast, things that move by nature are always in motion and never stop moving […][177]

This forces one to radically rethink the Aristotelian doctrine of motion, which is harshly criticized here. If a body, when dropped, falls down to the earth, this cannot be due to the fact that the body changes its state from 'motionless' to 'moving'. On the contrary, it is its desire to preserve its being that forces the body to fall down towards the centre of the earth. In Telesio's account, there, there are two main polarities: one between motion and immobility, [*motum and immobilitas*], understood as the nature charaterizing hot and cold things respectively, and therefore opposite one to another; and one between rest [*quies*] and labor [*labor*], characterizing a forced motion of things which are naturally at rest. As he writes,

> All motions […] appear to differ one from another negligibly, in contrast to motion and rest, which, as also Aristotle states, derives from a nature that is opposite to that of motion and indeed is really contrary and opposed to motion;

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[175] Aristotle, *Physics* (2006), Book IV.

[176] I, 43, 134: "Terram Coelo omnino contrariam esse, et nullum illi motum convenire, et absurdas esse Aristotelis rationes, quae motum illi naturalem et reliquis corporibus omnibus attribuunt, et cur deorsum sponte feratur."

[177] "At eque quae in proprio loco natura quiescere et immobilia esse videntur, sponte etiam suam ad illum deferri visa, proprio et naturali motu deferri videri debent; neque enim et immobilitas et motus naturae uni convenire, sed quae natura immobilia sunt motus omnis penitus expertia sint necesse est, quae contra natura moventur perpetuo moveantur oportet, et moveri nunquam cessant" (I, 44, 137–139).

> indeed, rest [*quies*] is opposed to labor [*labor*] not to motion thanks to which mobile entities [*mobilia entia*] rest [*quiescunt*] and take much pleasure and gain strength.[178]

The notion of *labor* here is particularly relevant to explain the motion of cold things, which by nature would otherwise not move at all. Heavy things (things predominantly characterized by the principle of Earth) do not move downward because that is their natural motion, but because they seek their own preservation. In seeking their preservation, they force their natural disposition to rest (if they are cold) or to move with uniform motion (if they are hot), moving with increasing speed towards the Earth or moving non-uniformly. As he writes,

> The parts of the Earth, separated from their place and their totality, fall spontaneously and the more rapidly the bigger they are and the closer they are to their place, not because that motion is natural to the Earth itself or to its parts but because the desire, the care and love of all beings for their preservation and for similar beings, and the hate of their destruction and of contrary beings, and the sense of both things, are such that they seem to force their nature, and the immobile beings move and the mobile beings move with an unusual, albeit natural, motion.[179]

The change in motion of warm, moving things is provoked by the interaction of external forces that threaten the preservation of their nature. Similarly, the downward motion of cold, earthly things is not a "natural" form of motion; rather they are forcing their own nature (arguably through what Telesio has just defined as "labor") until they can be one with the principle that ensures their self-preservation and increases their being. As Telesio writes,

> […] one shall not think that the parts of the Earth, while they fall towards their own place [*proprium locum*] and their own totality [*universalitatem*], move with natural motion, for once they have reached their totality they always become, like it, immobile; instead, one must think that they force their own nature and perform an action that is alien to their nature [*ipsae naturae inferre vim et alienam tantisper operari operationem*] until they reach their place and their totality.[180]

This leads to a second, and more interesting, criticism of the dichotomy between violent and natural motion. Telesio claims that what Aristotle describes as the natural, downward motion of heavy things cannot be the case, for it gradually increases, as Aristotle claims when he observes the fall of a stone towards the center of its sphere. In contrast, the motion of things that move by nature is uniform.

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[178] I, 43, 138: "[…] motus omnes, differre etiam inter se visos quid quam motum atque immobilitatem, quae vel Aristotelis testimonio ab opposita motui manat natura, et quae vere motui contraria est oppositaque; nam quies labori opponitur, non motui in quo vel summe quiescunt summeque oblectantur et robur etiam sumut mobilia quae sunt entia."

[179] I, 43, 138: "Terra itaque partes, a proprio loco et a propria abstractae universitate, sponte delabuntur sua eoque velocius quo maiores et quo proprio loco propinquiores factae sint, non quod naturalis is vel Terrae ipsius vel eius partium motus sit, sed quod, ut expositum est, is entium omnium propriae conservationis et cognatorum appetitus studiumque est atque amor, propriaeque destructionis et contrariorum odium atque aversatio et utriusque sensus, ut propriae etiam naturae vim inferre videantur, et immobilia moveantur, et mobilia, si quidem naturali, insueto certe motu."

[180] I, 43, 138–140: "Quaere nec Terrae partes ad proprium locum et ad propriam descententes universitatem naturali motu moveri videri debent, quae ad ipsam delatae perpetuo veluti et ipsa immobiles fiunt, sed et ipsae naturae inferre vim et alienam tantisper operari operationem, quo ad proprium locum et ad propriam ferantur universitatem."

Analogously, violent motion cannot be characterized by a progressive decrease of its intensity. Instead, "natural motion" is constant by nature, since "the bodies that move by nature, since motion is the operation by which they preserve themselves to the highest degree, must always move with the same speed."[181] Here, we probably find an echo of the widespread Aristotelian and Ptolemaic idea according to which the motion of heavenly objects is characterized by constant speed. In this way, changes in motion are brought about by the presence of an external force (which Telesio identifies as a contrary nature) that threatens the preservation of the thing itself, or, conversely, by the thing's drive to self-preservation:

> […] the bodies that increase continuously [their speed] move not by nature but either because they are pushed by some evil, and the more they hate it the more they increase their motion, or because they are attracted by some good, and the more they are enticed by its sweetness the more desirously they pursue it.[182]

On this basis, Telesio begins a very detailed confutation of the Aristotelian explanation of the increase of speed of a falling stone, which his doctrine of self-preservation is meant to replace. This confutation reveals, I believe, the motivations of Telesio's theories of sentience and self-preservation: his intention to provide an alternative to Aristotle's theory of motion. However, this motion cannot be deemed "natural", as natural motion, in Telesio's account, is characterized by constant speed and not by uniform acceleration. This overturns Aristotle's account of the difference between violent motion (characterized by progressive deceleration) and natural motion (characterized by constant acceleration).[183]

The increase of the speed of a falling object is at the center of Telesio's polemic. According to Aristotle, Telesio explains, the stone, while approaching the ground, progressively re-acquires its nature of heaviness, which it partially lost because of its distance from its natural place and the action of the contraries. But how can the air, which is very weak, deprive the stone of its nature, since once dropped the stone does not even stop for a second? And how can the Earth immediately re-introduce the nature of heaviness to the stone? What is more, in this way a stone that is lifted only a little should move more quickly than one that is lifted higher in the air, since its distance from the Earth is smaller;

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[181] "At neque qui motus assidue magis concitatur naturalis is propriusque, sed praeter naturam omnino videri debet, non siquidem in eo a naturali violentus differre, quod hic assidue magis languescat, ille vero assidue veluti robur sumat et magis concitetur, sed quod perpetuo idem est nihilque vel remittitur vel concitatur unquam. Quae scilicet natura moventur, quoniammotus propria ipsorum operatio est et qua summe in propria servantur natura, perpetuo eodem ferantur oportet" (I, 45, 142).

[182] "Quae itaque assidue illum concitant, non natura moveri videri debent, sed vel a malo aliquo impulsa quod assiudue magis abhorrescentia motum assidue concitant magis, vel a bono quopiam tracta cuius dulcedine magis assidue illecta maiore id sectentur studio […]" (145).

[183] "Propterea, quidam inquiunt, qui e sublimi dedicit lapis extremum et Terrae contiguum spatium velocius conficit, quod simili congataeque Terrae proximior factus, propriae naturae et propriae etiam gravitati quibus ab alieno loco et a contrariis veluti extus fuerat restituitur. Absurda sane ratio, et quae modis multis refelli possit" (145).

yet experience shows us the contrary.[184] In the second place, Telesio refutes the explanation based on the quantity of the medium. Accordingly, the stone would cut through the air below more easily the more it nears its natural place due to the decreasing quantity of air beneath it, and thus its motion would result in constant acceleration. Telesio deemed this explanation inconsistent. First, Telesio claims, the medium (air) is always the same substance. Second, the more the stone approaches its natural place, the more the medium must become dense due to the pressure that the falling object exerts. Third, the fact that the stone falls with less speed if dropped from a lower place represents a glaring confutation of this thesis.[185] Lastly, Telesio confutes the antiperistatic explanation. According to this theory, the motion of objects (both natural and violent) is caused by the displacement of air that the moving object provokes, since a vacuum cannot exist in nature and the air displaced by the moving object would fill the space left by the object, in turn propelling it. When applied to the fall of the object, the tendency it has to move downward combined with increased pressure and push of the air above it would explain the acceleration of the falling stone, which therefore would be proportional to the increase of the mass of air above it. Once again, Telesio harshly criticizes this explanation. First, as in the case of violent motion, things do not increase their speed by virtue of the action of the air but because of the force exerted on them.[186] The air still moves to fill any empty space left by the moving object but its impetus cannot be strong enough to cause the propulsion of the object itself. Moreover, how can the fact be explained that once the object leaves the hand it starts moving spontaneously, without any empty space having yet been created?[187] In addition, the increase of the quantity of air above the falling object cannot explain the increase in downward movement of the stone,

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[184] "Primum enim ne ipsi quidem qui ilam afferunt Peripatetici sibi ipsis (ut opinor) persuadeant, lapidem in sublime proiectum et nullo ibi temporis ammoratum momento a longe languidissimo aere propria natura propriaque exui gravitate, et leviorem omnino fieri, tum nullo itidem temporis momento a cognata Terra gravitatem illi indi; levitas enim gravitasque ne Aristoteli quidem agendi vi et se ipsas constituendi facultate praeditae videntur, sed illa quidem caloris, haec vero frigoris opus esse. Quoniam igitur paulo superior aer, non modo nihil inferiore calidior videri potest, sed vere frigidior existit, ut ad quem reflexa lux et languida et minus unita ascendit, nequaquam in eo levior fieri lapis videri potest. At ut calidior sit superior aer et levitas agendi vi praedita, non certe adeo nullo temporis momento lapidem tenuitate ulla aut ulla donent levitate, nec levior factus nullo itidem temporis momento gravior a cognata Terra fiat. Quin, si ea etiam omnia fiant, non vera sit ratio tamen, non scilicet Terrae proximior factus lapis propterea motum concitat, quod quae procul a Terra acto descendendi vires imminutae fuerant a propinqua Terra in integrum restituuntur; id enim si sit, ubi exiguum quid atollitur lapis nihil itaque levior fit spatium quo a Terra abest nihilo pigrius, forte etiam et velocius conficiat quam si e sublimiore decidat; secus omnino atque evenire videtur, quo enim a Terra minore sublatus est spatio, eo languidiore id delabitur motu, et eo idem vehementiore quo ex editiore descendat loco, ut manifeste descendendi vires non a Terra vicinitate, nec a re omnino alia ulla, at a descensus diurnitate augeri videantur" (147).

[185] 147.: "[…] quoniam enim lapidis magni praesertim delapsus aeris concessionem, et quasi fugam, praevenit atque antevertit, in angustius agatur suppositus aer atque in se ipsum conspissetur oportet, qui itaque dividi magis repugnet motum omnino descendentis lapidis impediat quid retardetque. At ex editiore is delabens extremum et Terrae contiguum spatium celeritate longe maxima, ex humili vero languidissimo illud idem conficere videtur motu."

[186] 148: "[…] quae vi proiiciuntur, nequaquam ab aere ea impellente, ut Aristoteli placet, sed ab impressa vi deferri videntur."

[187] 148: "[…] satis enim sit aeri ne spatium ullum vacuum fiat providere, et nullo temporis momento eo accurrere unde necessit, quid, at non eo tamen impetu feratur oportet, ut non repleat modo relictum spatium, sed quod inde abiit impellat etiam stimuletque, siquidem propria natura in proprio loco immobilis Aristoteli aer, nequaquam prompte ac libens moveatur; at id modo quod moveri necesse est. Parum itaque a manu dimotus lapis, vel statim potius ac manu emissus est, coincidat; neque enim inter manum lapidemque spatium ullum inane factum est ad quod replendendum aeri sit convolandum."

since only the air close to the object would be set in motion and not the rest of the air above it, which would tend to stay still.[188] Furthermore, this would have paradoxical consequences in the case of violent motion. Even assuming that air, which is a thin and weak substance, possesses the force to move even a small object, and assuming that this force would increase proportionally to the quantity of the medium (i.e. the higher the object is positioned), a stone thrust upward with violent motion would continue to move indefinitely, as the push imparted by the increasing quantity of air beneath would increase proportionally.[189]

On this basis, Telesio concludes that the Peripatetics could not find any convincing explanation for the non-uniform speed of falling objects. The explanation of the acceleration of the falling stone can thus only be based on the notion of sentience and on that of self-preservation: the stone hates contact with things that are contrary to its nature and increases its speed to enjoy, as soon as it can, its immobility among akin bodies.[190] As Telesio writes,

> The cause appears evident on the basis of what I have explained: that is, that the Earth, removed from its place and its totality, being immobile by nature, and hating very much this alien place and the contact with alien things, forces its nature and falls towards its own place and towards akin bodies; and this with increasing speed because, hating and being irritated by those [alien] things as much as by motion, it increases more and more the motion itself to enjoy as soon as possible its immobility among akin bodies.[191]

5. Conclusion

Telesio's argument relies on a strict analogy between human psychology and the natural world. The reason why earthly falling objects increase their motion is explained elsewhere through a comparison with the sense of anxiety (and at the same time of urgency) to reach pleasure or rest that we experience when we are doing something unpleasant:

> […] the more we deal with things that provoke annoyance to us, but that nevertheless we have to deal with, and that once they are finished give us pleasure and rest, the more we increase our motion [or activity] despite hating and being bothered by the effort, since we increasingly desire the pleasure and rest that we are about to achieve.[192]

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[188] "Tum si hac etiam ratione proiectorum motus fiat, non propterea aer universus ad Terram usque lapidem consectetur, sed proxima tantum assidue pars, quiescant reliquae et propria omnes gaudeant immobilitatem" (Ibid.).

[189] "[…] perpetuo itaque moveantur quae vi moventur omnia, si siquidem modica aeris pars satis Aristoteli est sursum lapidem atollere, multo ubi longe facta est maiori idem possit. At non si ab impressa vi et ab indito ferantur motu, sed eo assidue languidius moveantur, quo a propellente removeantur magis, quo nimirum vis motusque inditus magis debilitetur magisque languescat" (I, 47, 150).

[190] I, 47, 150.

[191] "A proprio videlicet Terrae loco atque a propria abstracta universitate, propria quidem natura immobilis, at summe alienum locum atque alienorum exosa contactum, naturae vim infert et ad proprium locum atque ad cognata delabitur corpora, assideque id velocius quod et aliena illa et ipsum itidem exosa peraesaque motum assidue illum magis concitat, ut quam celerrime inter cognata propria gaudeat immobilitate" (I, 47, 150).

[192] "[…] id quod nobis usu evenire interdum videntur; nam quae dum tractanctur molestiam inferunt, et peragenda omnino sunt, et quibus peractis voluptas proposita est et quies, quo magis ea tractamus eo motum magis concitamus, et opus exosi pertaesique et appropinquantis voluptatis quietisque magis appetentes" (I, 45, 144).

During the seventeenth century, this "anthropomorphization" of nature (or naturalization of human psychology) would no longer be taken as a valid means to explain natural phenomena. For instance, in *Principia Philosophiae*, Descartes used the famous example of a stone revolving in a sling in order to explain his proto-inertial understanding of rectilinear motion. As Descartes claims, if released by the sling the stone would move rectilinearly. Circular motion is therefore constrained rectilinear motion. In this respect, Descartes claims that the stone "strives" to move away from its center of revolution. But then he clarifies that his use of the expression "striving" does not entail any animistic hint:

> […] when I say that the globules of the second element 'strive' to move away from the centers *('recedere conantur ab istis centris'*) around which they revolve, it should not be thought that I am implying that they have some thought from which this striving proceeds. I mean merely that they are positioned and pushed into motion in such a way that they will in fact travel in that direction, unless they are prevented by some other causes (II, 56.)[193]

The main aim of this passage was likely that of avoiding any possible charge of endorsing the animistic interpretation of natural phenomena that had characterized some of the most important natural philosophies of the Italian Renaissance (such as Telesio's) or in general the widespread use of psychological jargon in the physical discourse that characterized Scholastic physics. However, while here we find ourselves miles away from Telesio's explanation of motion, it is hard not to see some interesting similarities between Telesio's understanding of motion in terms of self-preservation and cognate seventeenth-century theories. Indeed, the example of the falling stone shows that Telesio's notion of self-preservation is complementary to that of universal sensibility, and it is very likely motivated by the search for an explanation of the origin of motion alternative to that offered by Aristotelian physics. Moreover, its autotelic, non-finalistic and anti-providential character represents a trait of great discontinuity with respect to contemporary Scholastic physics. Providing a dichotomy between motion and rest, and understanding violent motion as a change of state due to the presence of an external force, it represents one of the first attempts to overcome the traditional Aristotelian picture of motion. In particular, when it comes to gravitation, his intuition that the downward motion of natural objects is not natural, but rather depends on the striving ("labor") of heavy objects to reconnect to their substance, strikes the readers as a clear detachment from Aristotelian-Scholastic physics.

While the notion of universal sensibility underlying this doctrine would generally be discarded by seventeenth-century mechanist philosophers, the idea that the behavior of physical objects can be explained in terms of a tendency to the preservation of states would characterize seventeenth-century proto-inertial natural philosophies. Two remarkable examples of this tendency can be found in Descartes and Spinoza. Descartes' first *law of nature* in *Principles of Philosophy* would be explained in terms of a tendency to the preservation of states ("everything tends, so far as it can, to persist in the

[193] Descartes, "Principles of Philosophy," 259.

same state" II, 37),[194] in turn rooted in the ordinary concourse of God. Spinoza would go as far as considering this striving towards self-preservation as the essential characteristic of all modes.[195] As I have shown, the explanation of the tendency of motion of bodies in terms of seeking self-preservation was not a unique trait of Telesio's natural philosophy but rather part of a widespread tradition. However, certain traits of Telesio's theory of self-preservation, such as the fact that the process lacks any kind of *terminus ad quem* and hetero-teleological determination, would become a fundamental trait of seventeenth-century mechanism. While it is hard to assess Telesio's influence on these (and other) authors, it seems to me safe to speculate that his theory of motion helped to create the intellectual atmosphere from which early modern mechanism stemmed.

[194] Ibid., 259.
[195] See for instance *Ethics* III, 6: "Everything, every thing, considered in itself, strives to persevere in its own being", in Spinoza, *Collected Works,* 498.

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