

**THE SCIENCE OF NATURE AND THE SCIENCE OF GOD:  
CONFLICT AND COLLABORATION  
IN THE EARLY MODERN PERIOD**

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This paper is a reflection on the results of a European Science Foundation Programme entitled 'From Natural Philosophy to Physics', which culminated in a conference in Granada in October 2007, where the paper was presented.<sup>1</sup> The programme was in part inspired by the conferences held in 1986, 1987 and 1993 to celebrate the work of Charles Schmitt, who, together with Charles Lohr, contributed most to the recent revival of interest in Renaissance Aristotelianisms (the use of the plural indicates that they took into account intellectual, religious, and national contexts in assessing the body of Aristotelian doctrines); and the Nijmegen conference of 1999 from which emerged the collaborative volume entitled *The dynamics of Aristotelian natural philosophy from antiquity to the seventeenth century*, whose editors - Hans Thijssen, Christoph Lüthy and Cees Leijenhorst - were instrumental in establishing the present European Science Foundation programme.<sup>2</sup> It would be appropriate also to mention the 1992 Wolfenbüttel summer school led by Eckhard Kessler from which was produced the volume entitled *Method and order in Renaissance philosophy of nature: the Aristotle Commentary tradition*, and a number of recent studies which have reassessed the relationship of the most notable *novatores* of the seventeenth century (Bacon, Galileo, Descartes, Hobbes) to the scholastic context in which they grew up, produced by Dennis Des Chene, Cees Leijenhorst and various contributors to the *Cambridge History of Renaissance philosophy*, the *Cambridge History of seventeenth-century philosophy* and the *Cambridge History of Early Modern Science*.<sup>3</sup>

<sup>1</sup> Full details of this programme may be found on the website:

<http://www.ru.nl/filosofie/center/esf/index.htm>. Dr. Tatiana Sedová represented the Slovakian Academy of Sciences on the Steering Committee; I should like to thank her for her encouragement to submit this paper to *Filozofia*.

<sup>2</sup> *Aristotelismus und Renaissance: in memoriam Charles B. Schmitt*, ed. Eckhard Kessler, Charles H. Lohr and Walter Sparr, Wiesbaden; Harrassowitz, 1988; *New perspectives on Renaissance thought: essays in the history of science, education and philosophy in memory of Charles B. Schmitt*, ed. Sarah Hutton and John Henry, London: Duckworth, 1990; *Philosophy in the sixteenth and seventeenth centuries: conversations with Aristotle*, ed. Constance Blackwell and Sachiko Kusukawa, Aldershot: Ashgate, 1999; *The Dynamics of Aristotelian natural philosophy from antiquity to the seventeenth century*, ed. Cees Leijenhorst, Christoph Lüthy and Johannes M.M.H. Thijssen, Leiden-Boston-Cologne: Brill, 2002, p. 6.

<sup>3</sup> *Method and order in Renaissance philosophy of nature*, ed. Daniel A. Di Liscia, Eckhard Kessler, and Charlotte Methuen, Aldershot: Ashgate 1997; Dennis Des Chene, *Life's form: late Aristotelian conceptions of the soul*, Ithaca and London: Cornell University Press 2000; *The Cambridge history of Renaissance philosophy*, ed. Charles B. Schmitt and Quentin Skinner, Cambridge: Cambridge University Press 1988; *The Cambridge history of seventeenth-century philosophy*, ed. Daniel Garber and Michael Ayers, 2 vols., Cambridge: Cambridge University Press 1998; *The Cambridge history of science, vol. 3: early modern science*, ed. Katharine Park and Lorraine Daston, Cambridge: Cambridge University Press

A certain coherence can be found in all of these undertakings about which it is useful to be explicit, in order to assess the revisions made by the present programme to existing histories of early modern science: science understood here in the limited sense of a ‘disciplined enquiry into the phenomena and order of the natural world.’<sup>4</sup> The first commitment, explicitly stated by this programme’s organisers, is to the abandonment of the view propounded by Herbert Butterfield and Alexandre Koyré that the seventeenth century witnessed a scientific revolution which constituted ‘the real origin both of the modern world and the modern mentality.’<sup>5</sup> As the editors of the *Cambridge History of Early Modern Science* put it, ‘it is no longer clear that there was any coherent enterprise in the early modern period that can be identified with modern science, or that the transformations in question were as explosive and continuous as the analogy with political revolution implies.’<sup>6</sup> As a consequence, the idea of a discontinuity and successive Kuhnian paradigms did not find favour with them; instead, the periodisation of medieval, Renaissance and early modern has been abandoned as an inappropriate historical construct, and emphasis has been laid on continuity, according to which even Hobbes’s natural philosophy looks ‘more like a hybrid than a revolution.’<sup>7</sup>

A second commitment of this programme is to the importance and vigour of Renaissance Aristotelianism: not a monolithic and internally consistent interpretation of Aristotle whose conceptual sterility and weak explanatory force was soundly denounced by the *novatores*, but rather an ensemble of elements in which no single tenet or group of tenets can be given the status of a necessary ingredient; in other words, a polythetic discourse incorporating shared beliefs about causality, matter, and metaphysics, defined (in the words of Charles Schmitt) by ‘common source materials, a common terminology, a common set of definitions, and a common method of discussing these problems.’<sup>8</sup> Already in the medieval period, there were within this discourse competing versions of Aristotelianism, as is well known; the recovery of Greek texts and Greek commentators and the employment of new analytical tools added to the diversity of interpretations of the *libri naturales*, and the effects of religious schism in the sixteenth century further complicated the picture.

The third commitment of the programme is to a combination of internalist and externalist analyses of texts. Of the four teams which were set up in the European Science Foundation programme, one was explicitly charged with investigating the institutional, cultural, social, political and religious contexts in which thinking about natural philosophy took place, and the effect of modes of transmission on the scientific thought; the other three teams were more concerned with doctrines and theories.<sup>9</sup> The decision to

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2006.

<sup>4</sup> *ibid.*, pp. 2 – 3.

<sup>5</sup> *Ibid.*, pp. 12 – 13.

<sup>6</sup> *Ibid.*

<sup>7</sup> Cees Leijenhorst, *The mechanisation of Aristotelianism: the late Aristotelian setting of Thomas Hobbes’ natural philosophy*, Leiden-Boston- Cologne: Brill, 2002, p. 222. See also Michael Edwards, ‘Aristotelianism, Descartes and Hobbes’, *The Historical Journal*, 50 (2007), 449-64; for Kuhnian paradigms, see below, note 32.

<sup>8</sup> *Aristotle in the Renaissance*, Harvard: Harvard University Press, 1983, p. 10

<sup>9</sup> Two proceedings have so far been published: *Transmitting knowledge: words, images and instruments in early modern Europe*, ed. Sachiko Kusukawa and Ian Maclean, Oxford: University Press,

examine not just bodies of scientific knowledge and the methods and logic employed to obtain them but also the relationship of mind to world offered a considerable enrichment to traditional history of science. The commitment to continuity and the broad canvas on which these topics was to be mapped indicates that one of the ambitions in the minds of the organisers has been that new grand narrative might emerge, which would account for the passage from natural philosophy to physics in a new way.

The present project of re-examining the passage from natural philosophy to physics is thus explicitly one which seeks to set the historical record straight (or as straight as it can be for any one generation of historians) in some or all of the following ways: by identifying errors or incomprehension in the work of its predecessors; by taking into account data which was not used by them, or by eliminating material used by them which is not now seen as pertinent; by exposing and eradicating a bias in their narratives, which might arise from an ideological commitment (of which the historians themselves might have been aware or unaware) or from the employment of a restrictive theory or method of historical enquiry which inflected their results. A more cynical review of the programme might have characterised it as a piece of historical revisionism, in which the rewriting of history is to be seen as a consequence of the academic profession's need to justify itself by modifying or rejecting the conclusions of its predecessors; but even if this is acknowledged as a factor, it does not nullify the noble pursuit of disinterested historical truth to which those engaged in this programme manifestly subscribe.

As well as the explanatory structure which accounts for the evolution of thought, there are (at least) four components in any narrative which seeks to account for the sort of historical change under consideration by this programme: ideas and theories, thinkers who think them, the institutions in which they and their ideas have their being, and the mechanisms through which they are communicated to others. These have not always been clearly distinguished. Minimalist histories of thought limit themselves as far as possible to ideas and theories. The more abstract the ideas and theories are, the easier it is to treat them as disembodied idealities, and if a common notation can be found for them, it is possible to mark their succession with almost no reference to thinkers, institutions and modes of transmission. But this will not tell the historian why they came about; to find this out, one has to discover to what questions they are answers. The logic of the medieval period has a complex history of its own which can be set down in symbolic form; but the reason why thinkers resorted to logic is to be found in doctrinal debates about theological dogmas such as the Incarnation and the Eucharist.<sup>10</sup> These motivating questions may reside in individuals; they may also reside in institutions, the study of which has given rise to increasingly sociological analyses, culminating in the work of those who have shown the role of aristocratic patronage in the development of early modern science, and the extension of scientific enquiry beyond the universities.<sup>11</sup> Much recent work has been done

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2006; and *Mechanics and cosmology in the medieval and early modern period*, ed. Massimo Bucciantini, Michele Camerota and Sophie Roux, Florence: Olschki, 2007.

<sup>10</sup> See for example Cees Leijenhorst and Christoph Lüthy, 'The erosion of Aristotelianism: confessional physics in early modern Germany and the Dutch Republic', in the *Dynamics of Aristotelian philosophy*, pp. 349-74. But this would not have to apply to all those engaging in logical or philosophical enquiry; they might just be responding to the logical problem, not its motivation.

<sup>11</sup> Much-cited examples of this approach are Mario Biagioli, *Galileo courtier: the practice of*

on why certain scientists engaged in certain areas of research which do not seem to fit easily into a positive history of scientific progress - why Newton, for example, concerned himself with alchemy and biblical chronology - and this has often revealed religious motivations which are not evident in their straightforwardly scientific work. The pioneer of such studies in the modern period is Walter Pagel, in his seminal article 'Religious motives in the medical biology of the seventeenth century' of 1935.<sup>12</sup>

It is more usual however to find religious motivation (or its converse: free-thinking) associated with institutions. J.H. Randall's linking of Paduan (Averroistic and materialist) Aristotelianism with the emergence of modern science provides us with an example. There can be fruitful interaction between the motivations of individuals and institutions, as in the case of the Hartlib circle in mid-seventeenth-century Europe, who according to the account given by Charles Webster in *the Great Instauration*, espoused millenarist views and linked these to a Baconian programme promoting the beneficial manipulation of nature; this has been taken further by Peter Harrison, who has argued that the new science of the seventeenth century is grounded in an 'Augustinian anthropology' which derives its justification for the exploitation of nature and the investigation of its workings from the theology of the Fall; he has amended the picture by suggesting that science is not seen as a vehicle of progress or a triumphant fulfilment of the mankind's intellectual potential but rather as a deficient *pis-aller* which reflects the weakness of human reason.<sup>13</sup>

Individuals can also be seen to be in conflict with the institutions they inhabit. For example, Jesuit science in the first third of the seventeenth century is determined by the rules under which teachers were placed by their vows of obedience to the Church and to their Order. In the eyes of Descartes, to whom heliocentrism and the motion of the earth are inescapable conclusions to be drawn from the available evidence, this turned the intelligent Jesuit astronomer Christoph Scheiner into an intellectual hypocrite, in that he must have been privately persuaded of the Copernican position, but argued against it in the *Rosa ursina*.<sup>14</sup> This severe view has been rejected by recent scholars of the Jesuits, such as Marcus Hellyer, who argue that they were neither backward nor duplicitous, but 'educators who [...] generally reconciled to their own satisfaction the demands of their theology, their natural philosophy, and their identities as Jesuits.' Hellyer is thus able to reject the view that links scientific progress to (Baconian) Protestantism and sees Catholicism and science as incompatible; he denies as a consequence that 'backward Jesuit science [...] somehow stunted the intellectual, cultural, or even moral development of Catholic Germany.'<sup>15</sup> The points which emerge from these examples to which I shall

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*science in the culture of absolutism*, Chicago and London: University of Chicago Press, 1993, and Stephen Shapin, *A social history of truth: civility and science in seventeenth-century England*, Chicago and London: Chicago University Press, 1994.

<sup>12</sup> 'Religious motives in the medical biology of the XVIIth century', *Bulletin of the Institute of History of Medicine*, 3 (1935), 265-312. For a more general survey, see *Heterodoxy in early modern science and religion*, ed. John Brooke and Ian Maclean, Oxford: Oxford University Press, 2006.

<sup>13</sup> J.H. Randall, *The School of Padua and the emergence of modern science*, Padua: Antenore, 1961; Charles Webster, *The great instauration: science, medicine and reform 1626-1660*, 2nd ed., Oxford-Bern-Berlin-Bruxelles-Frankfurt am Main: Lang, 2002; Peter Harrison, *The fall of man and the foundations of science*, Cambridge: Cambridge University Press, 2007.

<sup>14</sup> Descartes, *Oeuvres*, ed. Charles Adam and Paul Tannery, Paris: Vrin, 1996, i..281-2.

<sup>15</sup> Marcus Hellyer, *Catholic physics: Jesuit natural philosophy in early modern Germany*, Notre

return are the ability of thinkers to compartmentalize their minds, and the varying status both of criteria for truth and its metaphysical underpinning, or more precisely, of ‘duplex veritas’ and the nature of certainty in different discourses.

To make my task of showing what this programme has achieved easier, I shall now give a short and no doubt tendentious history of grand narratives which set out to explain how natural philosophy came to take on the character of physics; then offer some thoughts on the historiographical issues raised by these narratives, giving examples wherever possible from the early modern period; and finally offer some of my own suggestions about these in respect of the programme in which we are currently engaged.

The first history of the passage from natural philosophy to physics in the period which is of concern to us is that offered by French Enlightenment thinkers, which depends very much in turn on the claims made by the *novatores* of the so-called scientific revolution. According to this story, between the thinkers in antiquity (including the Aristotle of the zoological books) and the coming of Francis Bacon, there was a dark age characterised by superstition, empty verbiage, logic-chopping, vapid metaphysics and neglect of the application of knowledge to the real world. The narrative underlying the progress in science is that of the gradual emancipation of the world from the deleterious control of religion in the form of Roman Catholicism; the freedom of thought from such ideological constraints and the principle of untrammelled rationality were traced to a group of Renaissance thinkers who had been stridently attacked by the Church for their libertinage in the early years of the seventeenth century, and to the English (rather than French) scientists who established what is called the ‘la philosophie expérimentale’. In the articles under this entry and under ‘physique’, ‘métaphysique’, ‘aristotélisme’ and ‘scholastiques’, the period between the ancient world and the seventeenth century is dismissed in a sentence or two.<sup>16</sup> The Enlightenment was clearly committed to a belief in human progress: as Jean Liron put it in 1738, ‘a time will come for both the natural history and the knowledge of nature when enlightenment will succeed the dark ages completely, and all the scattered parts [of knowledge] will take their place of themselves, and will adjust themselves, to the system of truth’<sup>17</sup> In this grand optimistic narrative, a secular providential account of human history is linked to the conflict between religious institutions and the investigation of nature. The mutual hostility of theology and natural philosophy depicted here represents the oldest of the three possible versions of this relationship. We shall meet the two others - coexistence, and collaboration- in more recent historical writing.

The first half of the nineteenth century witnessed the emergence of other grand narratives of human progress: From our point of view, the one which matters most to science in its relationship to theology emerged at the beginning of the twentieth century in the work of Max Weber, who was heir to the debates about Hegelian idealism, the positivist history of Leopold von Ranke which incorporated a Lutheran version of

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Dame: University of Notre Dame Press, 2005, pp. 240 – 244.

<sup>16</sup> *L'Encyclopédie ou dictionnaire raisonné des sciences, des arts et des métiers*, Paris: Briasson, David, Le Breton and Durand, 1751-65, sub vv.

<sup>17</sup> *Singularités historiques et littéraires*, Paris: Didot, 1738, i.xii: ‘il viendra un temps pour l’histoire comme pour la connaissance de la nature, où la lumière succédant tout à fait aux ténèbres tous ces morceaux épars prendront d’eux-mêmes leur place et s’ajusteront au système de la vérité.’

providentialism, and of course Marxism. Weber coined the term ‘Entzauberung’ to describe the progressive secularisation of the Western World; he also postulated four levels of rationality, which although most applicable to sociology and economics, have a role to play in the history of scientific thought. The bottom level, traditional rationality, is impregnated by values of which its practitioners are not aware (that is, they belong to the age of magic): those who operate by affective rationality can articulate their values, but not evaluate them; value rationality allows its adherents to be explicit about their values and the reasons for having chosen them; and instrumental rationality involves the analysis of ends and means without the privileging of any values at all.<sup>18</sup> We have to decide whether the medieval philosophers and their successors who dealt with religious or intellectual values, were aware of them, and evaluated them, or were driven by motivations of which they were not fully conscious. We may remember in this regard the suggestion of A. N. Whitehead in *Science and the modern world* that ‘when you are criticizing the philosophy of an epoch, do not chiefly direct your attention to those intellectual positions which its exponents feel it necessary to defend. There will be some fundamental assumptions which adherents of all the various systems within an epoch unconsciously presuppose. Such assumptions appear so obvious that people do not know what they are assuming because no other way of putting things has ever occurred to them.’<sup>19</sup> It is not clear whether he is referring here to ideological determinants, or what Gaston Bachelard referred to as ‘epistemological obstacles’.<sup>20</sup> I shall come back to the presumption of blindness in past thinkers at the end of this paper.

Another, more modern, concern with the thesis of secularisation arises from the process which has now been given the name of confessionalisation, that is, the state-driven disciplining of communities by force, censure, persuasion and ritual, and the dispensing of propaganda through catechisms, the arts and education in schools, colleges and universities. Whether confessionalisation is an epiphenomenon of secularisation (in that it acknowledges the relativity of religious truth) or its opponent (in that it imposes a religious character on the communities it regulates) is much debated<sup>21</sup>; but it is worthy of note here that scholars have recently argued that it plays a role in the choice made by natural philosophers of different religious denominations in respect of the physics of place and of substance (the issues of the ubiquity of Christ’s body and the Eucharist), and in the revival of the fortunes of metaphysics in Catholic, Lutheran and reformed contexts at the end of the sixteenth century.<sup>22</sup>

The stage is now set for the writers of grand narratives who which still affect our view of the past today. The first, but very much not least, of these is Pierre Duhem. He is responsible for the nationally inspired taxonomy of styles of mind, the narrow and deep French being enamoured of abstract, simple theories, the broad and shallow English of a clutter of concrete details, and the German being a debased version of the French mind,

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<sup>18</sup> *Wissenschaft als Beruf*, Berlin: Duncker and Humblot, 1919; *Wirtschaft und Gesellschaft*, Tübingen: Mohr, 1921.

<sup>19</sup> *Science and the modern world*, Cambridge: Cambridge University Press, 1925, pp. 49-50.

<sup>20</sup> *La formation de l’esprit scientifique*, Paris: Vrin, 1938, pp. 14-19.

<sup>21</sup> See Philippe Büttgen, ‘Histoire doctrinale, histoire culturelle de la confessionalisation’, *Études Germaniques* 57 (2002), 558 – 576.

<sup>22</sup> See below, note 47.

in that too much emphasis is laid on logic. These propensities are not literally national, insofar as there are English thinkers who have a French mind (Newton), although it has to be said that most examples of English thinking are in fact found in Englishmen (Faraday and Maxwell). Duhem was a considerable theoretician of physics in his own right, being best known for his claim (as recorded by Quine) that ‘our statements about the world face the tribunal of sense experience not individually but as a corporate body’; in other words, if error lies in an experiment, it can arise from any of the propositions used to predict the outcome; as empirical statements are interconnected, they cannot be singly disconfirmed; fact is completely interpenetrated by theoretical interpretation. This view committed Duhem in turn both to the view that physics was progressing towards the asymptote of an ideal theory, and to the importance of continuity in physical theory. He thought therefore that it was necessary to know the past in order to evaluate the present state of science; for him science’s past began in 1277, with certain of the propositions of Bishop Tempier’s notorious Parisian condemnation (a view scornfully rejected later by Alexandre Koyré). His studies of Leonardo da Vinci and Galileo led him to a rehabilitation of ‘Parisian’ medieval science (in which the Merton calculators were conspicuous by their absence).

Duhem, a pious conservative Catholic in a French scientific world dominated by anticlerical liberals, was attacked by other Catholic scientists for his dismissal of metaphysics from the realm of physics.<sup>23</sup> He was criticized for other reasons by Anneliese Maier, who accused him of treating medieval natural philosophy as though it was preoccupied with modern problems, and who strongly argued the case for discontinuity in scientific endeavour. This led her to attempt to recreate medieval science in its broader philosophical context and in respect to what have come to be called ‘actors’ categories’; she saw no continuity with the modern world in such concepts as time and motion, but sought to define them in a way which did not reduce their alien nature.<sup>24</sup> After her, Alexandre Koyré amended other aspects of Duhem’s history: he stressed revolution in science, highlighted the role of metaphysical presuppositions, argued for the significance of failed theories, and for the greater importance to be placed on the articulation of scientific problems than the achievement of results. He was the first historian to abandon a straightforwardly progressivist view of the history of science.<sup>25</sup> His analysis was highly internalist; across the Atlantic, meanwhile, Lynn Thorndike looked for a different ancestor of seventeenth-century experimental science in medieval alchemy and magic, which he saw as inextricably combined with the natural and mathematical science of the time, and which led him to speculate whether Renaissance humanism impeded the progress of science: a suggestion taken up by George Sarton and later Alistair Crombie.<sup>26</sup> A further aspect of Duhem’s and Thorndike’s work – their characterisation of the study of

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<sup>23</sup> On Duhem, see the excellent recent article by Roger Ariew in the on-line *Stanford Encyclopedia of Philosophy*.

<sup>24</sup> *Studien zur Naturphilosophie der Spätscholastik* 5 vols, Rome: edizione di Storia e Letteratura, 1949-58.

<sup>25</sup> *Etudes galiléennes*, Paris: Hermann, 1966; *Du monde clos à l’univers infini*, Paris: Gallimard, 1973.

<sup>26</sup> *A history of magic and experimental science*, 8 vols, New York: Columbia University Press, 1923-58; George Sarton, *Introduction to the history of science*, Baltimore: The Johns Hopkins University Press, 1953; A. C. Crombie, *Styles of scientific thinking in the European tradition*, London: Duckworth, 1994.

nature as an evolving endeavour – has been subjected to scrutiny in a recent debate which opposed Andrew Cunningham and Edward Grant, the former defending the thesis that natural philosophy as a discipline throughout the medieval and Early Modern period was inherently theological, the latter that natural philosophy was free from theological concerns, and a direct ancestor of modern science.<sup>27</sup> Thorndike's thesis has been vigorously attacked by Brian Vickers, who argued that the occult sciences (alchemy, astrology, numerology and natural magic) and science represent two quite separate mentalities.<sup>28</sup> A rather different development of Thorndike's work is to be found in the studies of the transmission of scientific knowledge by practitioners and artisans, which directed the efforts of members of the elite to the design of instruments and the practical uses of mathematics.<sup>29</sup>

Meanwhile, another group of revisionist historians were setting to work on other aspects of the story. I shall only mention three whose work has been important to this programme, all of whose seminal works appeared in the early 1960s. Richard Popkin, picked up the Enlightenment and Weberian story of secularisation, and argued that scepticism is a dominant factor in the weakening of religion and the emergence of the new science. Recent studies of his work have set out to show that his account suffers from being a back-projection from Spinoza's secular rationalism, and fails to take into account the much longer history of the practice of 'free philosophizing'.<sup>30</sup> The other two historians to be mentioned here, Thomas Kuhn and Michel Foucault, offered discontinuous histories of modes of thought, which separate radically the thinkers of the seventeenth century from their predecessors. But increasingly, doubt has been cast on the unity and coherence of the 'scientific revolution', in spite of these influential accounts of paradigms and epistemes.<sup>31</sup> It only remained for Schmitt and Lohr to revive the fortunes of Aristotelians and for Cunningham and Harrison to argue for the theological component of both Catholic and protestant natural philosophy for us to discover that all the features described as negative in the Enlightenment account – the sterility of medieval science and Aristotelianism, religion as a repressive force, theology as a barrier to scientific progress – have been revalorised as positives to some degree.

The last grand narrative I shall mention is contemporary with the ESF project, and is being undertaken by Stephen Gaukroger, in a multi-volume work whose first substantial part entitled *The emergence of a scientific culture: science and the shaping of modernity*,

<sup>27</sup> The battle lines are clearly set out by Andrew Cunningham and Edward Grant in *Early Science and Medicine*, 5 (2000), 258-300. See also John Hedley Brooke, Margaret J. Osler and Jitse M. van der Meer, *Science in theistic contexts: cognitive dimensions*, Osiris 2.16, Chicago, 2001.

<sup>28</sup> *Scientific and occult mentalities in the Renaissance*, ed. Brian Vickers, Cambridge: Cambridge University Press, 1984.

<sup>29</sup> See Jim Bennett, 'Operative knowledge', *Configurations* 6 (1998), 195-222.

<sup>30</sup> Richard Popkin, *The history of scepticism from Savonarola to Bayle*, New York and Oxford: Oxford University Press, 2003 (earlier version in 1962 and 1979); Ian Maclean, 'The "sceptical crisis" reconsidered; Galen, rational medicine and the *libertas philosophandi*', *Early Science and Medicine*, 11 (2006)247-74.

<sup>31</sup> Thomas S. Kuhn, *The structure of scientific revolutions*, 2nd ed., Chicago and London: Chicago University press, 1970; Michel Foucault, *Les mots et les choses*, Paris: Gallimard 1966; id., *L'archéologie du savoir*, Paris; Gallimard, 1969; see also *Criticism and the growth of knowledge*, ed. Imre Lakatos and Alan Musgrave, Cambridge: Cambridge University Press, 1970; *Cultural history after Foucault*, ed. John Neubauer, New York: Aldine de Gruyter, 1998.



*1210-1685* appeared in 2006. For him, the success of modern science is explained by not adversarial non-dogmatic argument, nor by the abandonment of authority in the sphere of philosophy, nor by dissociation from religion, nor by technological benefits (all elements of previous narratives). His story is one which recognizes the function of medieval metaphysics as a bridge between natural philosophy and revelation, and sees the mechanical philosophy of the seventeenth century as the reestablishment after a period of turbulence of the mutually reinforcing roles of revelation and science. In his largely anglocentric account of the late seventeenth century, one of the most important factors is the emergence of the persona of the natural philosopher, a person committed to a belief in the unity of knowledge, to objectivity and impartiality, and to the removal from the field of natural enquiry of all impositions of boundaries.<sup>32</sup>

How are we to adjudicate between these competing accounts? To do this, it is probably helpful to state the ways in which they are not strictly commensurable:

1. They take different bodies of evidence into consideration. There was a move in the twentieth century to exploit sorts of evidence that had previously been excluded from the historical record: manuscripts which had lain dormant in libraries for many centuries, whose content had been forgotten or lost by subsequent generations; and books which were disregarded because they were thought to contain nothing other than what Kuhn called 'normal science'.<sup>33</sup> In the first case, some remarkable figures were resurrected – John Buridan and Nicolas Oresme among them – who, although they revealed the potentialities of medieval thinking, cannot be said to have a posterity; in the second, the close reading of textbooks and commentaries of the Aristotelian tradition showed that a far greater intellectual diversity than hitherto thought enriched the picture of cultural life in the Renaissance (in spite of the normalizing effects of the genre of disputation and commentary), but this does not alter the fact that through the activities and propaganda of the *novatores*, these writings were soon lost to posterity.

2. These grand narratives give different priorities to ideas and theories, the thinkers themselves, the institutions which they inhabit and resist, and the means they use to communicate with each other. One may wish to claim that the purest form of the history of science considers only ideas, theories and the arguments and evidence which support them; but even this position is difficult to hold, as one can study comparatively different aspects of the intellectual practices of different groups of natural philosophers. Hence the modern distinction between the historians of philosophy, who give greater weight to, say, metaphysics, and historians of science proper, who are more concerned, say, with mathematical issues. We have seen that the conceptual schemes inhabited by medieval and early modern natural philosophers (whether considered as individuals or as members of a *Denkkollektiv*<sup>34</sup>) have been characterised in various ways. In many cases, individuals inhabit a number of these conceptual schemes, intermittently or permanently, which they

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<sup>32</sup> Stephen Gaukroger, *The emergence of a scientific culture: science and the shaping of modernity, 1210-1685*, Oxford: Oxford University Press, 2006.

<sup>33</sup> See note 32.

<sup>34</sup> The term designates a community of persons mutually exchanging ideas or maintaining intellectual interaction, and comes from Ludwik Fleck, *Genesis and development of a scientific fact*, trans. Thaddeus J. Trenn, introd. Thomas S. Kuhn, Chicago and London; Chicago University Press, 1979.

may strive to unite or keep apart. Rivka Feldhay, Gaukroger, and others talk about *novatores* who attempt to ‘sacralize’ natural knowledge (one may think here of Melanchthon’s combination of Lutheran providentialism with the study of anatomy), or introduce natural philosophy into theology and biblical hermeneutics, or are applauded by their contemporaries for practising both disciplines<sup>35</sup>; but these and other forms (both Catholic and protestant) of ‘*physica sacra*’ or Mosaic physics coincide with texts which radically separate the investigation of Holy Scripture and that of the book of nature, perpetuating the medieval Albertine distinction of ‘*physice* [or *philosophice*, or *naturaliter*] loquendo’ and ‘*theologicice loquendo*’, and arguing that the criteria for validity (whether truth, certainty, or coherence) are quite distinct in the two disciplines.<sup>36</sup> One form of segregation suggests that thinkers ensure that the two disciplines are autonomous; another suggests coexistence but not interpenetration (as in the case of Descartes, who underpins his physics with metaphysics, but does not allow the latter to impinge on the former); in yet others, a space is left for the operation of theology inside physics, as in the case of Newton, who according to Feldhay ‘insists on the essential role of God in a mechanical universe’.<sup>37</sup>

All of this presupposes a very high degree of awareness by actors and their contemporaries of the full implications of their theories. But is equally plausible that generations of thinkers are not fully aware that their own means of expressing their thoughts to themselves and to their contemporaries may disguise ambiguity and incoherence in their terminology. It is uncontroversial to claim that it takes a scientific community some time to work out the full implications of new ideas and theories, all the more so if they are used in more than one disciplinary context. Such concepts as species, genre, and certainty, used in natural philosophy, medicine and theology offer examples of this.<sup>38</sup> Moreover, the form and vehicle of scientific communication can also affect the transmission in ways which may compromise the pure ideality of any theory by making part of its content dependent on the way it is expressed. Some of the studies undertaken in this programme have given instances of this in various contexts, including the use of diagrams and the genre of the scholarly journal.<sup>39</sup>

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<sup>35</sup> Rivka Feldhay, ‘Religion’, in *The Cambridge history of science: early modern science*, pp. 727-55, esp. 755, quoting Frank Manuel; ‘In the England of the Restoration [...] where so many divines doubled as scientists, the co-existence in one head of expert knowledge in both books [sci. Scripture and nature] came to be respected, and the capacity of a man to reveal the glory of God in both spheres was taken for granted.’ Also Sachiko Kusukawa, *The transformation of natural philosophy: the case of Philip Melanchthon*, Cambridge: Cambridge University Press, 1995.

<sup>36</sup> Ann Blair, ‘Mosaic physics and the search for a pious natural philosophy in the late Renaissance’, *Isis*, 91 (2000), 32-58.

<sup>37</sup> Rivka Feldhay, ‘Religion’, in *The Cambridge history of science: early modern science*, pp. 753-4.

<sup>38</sup> On these terms, see Ian Maclean, ‘Expressing nature’s regularities and their determination in the late Renaissance’, in *Natural law and the laws of nature in early modern Europe*, ed. Lorraine Daston and Michael Stolleis, Aldershot: Ashgate, forthcoming.

<sup>39</sup> Jeanne Peiffer and Jean-Pierre Vittu are presently engaged on a research project concerning learned periodicals in the seventeenth and eighteenth centuries, and the different ways in which mathematical information is transmitted through them and through other means; they presented a paper in the European Science Foundation programme in 2004, and organized a workshop on the topic at the Herzog August Bibliothek, Wolfenbüttel in 2005.

Against this, we can site at least one area whose revival shows how alert early modern thinkers were to the transformations taking place in natural philosophy and theology, and how important the reaction of institutions to these were. I refer to the discipline of metaphysics. Charles Lohr has shown how Benito Pereira reconfigured this in a Catholic context to accommodate natural philosophy to the demands of the Lateran Council and the Council of Trent; there have been several recent studies of the bitter debates in Lutheran Universities at the end of the century which raised again the question of the unicity of philosophical and theological truth; Howard Hotson's most recent book looks at the role of metaphysics in the post-Ramist reformed communities throughout Europe.<sup>40</sup> There is even an Anglican example which one might cite; Thomas Harriot's Nachlass reveals his own struggles with the mass of Aristotelian metaphysical presuppositions which, as he expressed it to Johannes Kepler, were bogging down English philosophical enquiry.<sup>41</sup> Yet another example is afforded by Andrea Cesalpino, who ingeniously reinterpreted Aristotle's strictures on definition and accident in the *Metaphysics* (vii.12) in order to develop a new concept of plant taxonomy; he was opposed in this by Nicolaus Taurellus, a self-proclaimed Christian philosopher, who at the same time as he valued empirical observation and evidence, the rejection of argument from authority, and the practice of 'free philosophizing', declared that he underpinned his natural-philosophical thinking with a metaphysics derived from an irenic version of Lutheran providentialism.<sup>42</sup> It may be true that after Bacon, less interest is shown in the most intrusive forms of metaphysical discussion (that of the nature of causality<sup>43</sup>); but I still think that one can infer from the above examples that these thinkers show a remarkable degree of awareness of the logical and institutional consequences of arguments on the frontiers of theology and natural philosophy. I am therefore not sure where Whitehead would discover their 'unconscious presuppositions', or Bachelard their epistemological obstacles.

3. A third point in which the grand narratives I have mentioned differ is in the ways they are marked by the circumstances and time of their production; this includes also their

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<sup>40</sup> Charles Lohr, 'Metaphysics and natural philosophy as sciences: the Catholic and protestant views in the sixteenth and seventeenth centuries', in *Philosophy in the sixteenth and seventeenth centuries: conversations with Aristotle*, pp. 280-95; Markus Friedrich, *Die Grenzen der Vernunft: Theologie, Philosophie und gelehrte Konflikte am Beispiel des Helmstedter Hofmannsstreits und seiner Wirkungen auf das Luthertum um 1600*, Göttingen: Vandenhoeck and Ruprecht, 2004; Howard Hotson, *Commonplace learning: Ramism and its German ramifications*, Oxford: Oxford University Press, 2007.

<sup>41</sup> Ian Maclean, 'Harriot on combinations', *Revue d'histoire des mathématiques*, 11 (2005), 57-78

<sup>42</sup> Kristian Jensen, 'Description, division, definition – Caesalpinus and the study of plants as an independent discipline', in *Renaissance readings of the corpus Aristotelicum*, ed. Marianne Pade, Copenhagen: Museum Tusulanum, 2000, p. 185-206; Ian Maclean, 'Arnau's reception in the sixteenth century: a supplement to Giralt', in *Between text and patient: festschrift for Michael McVaugh*, ed. Brian Nance and Florence Eliza Glaze, Florence: Micrologus Sismel, forthcoming.

<sup>43</sup> Lynn S Joy, 'Scientific explanation from formal causes to laws of nature', in *The Cambridge history of science: early modern science*, p.72, talks of 'the waning of interest in metaphysical discussion of the nature of causality itself and the increase in interest in producing natural effects.' See also Ian Maclean, 'White crows, graying hair and eyelashes: problems for natural historians in the reception of Aristotle's logic and biology from Pomponazzi to Bacon', in *Historia: Empiricism and Erudition in Early Modern Europe*, ed. Gianna Pomata and Nancy Siraisi, Cambridge, Mass.: MIT Press, 2005, pp.147-80.

notion of narrative and of historical change. It is not difficult to show that scientific preoccupations current at the time of the writing of any history of science affect its representation of the past.

The most extreme form of this is found in logical back-projection of the present state of a science without any real interest in the empirical facts. Jean-Jacques Rousseau provides the clearest statement of this in his *Discours sur l'origine et les fondements de l'inégalité parmi les hommes* of 1755, where he confesses that his reconstruction of the origins of human society describes a state which 'no longer exists, perhaps never existed, and probably will never exist, but about which is necessary for us to have correct notions, if we are to evaluate correctly our present state.'<sup>44</sup> The opposite extreme would be an unselective descriptive history, such as that attempted by Maier or Thorndike. The most recent histories of early modern science tend to combine the two approaches by accepting the provisional nature of any historical narrative and the motivations which may underlie any attempt to give an account of the past, at the same time as employing the widest range of sources and methods of analysis. Dennis Des Chene's *Life's form*, for example, sets out to study the science of the soul using actors' categories in an attempt not to reduce or disguise the otherness of the past, but he allows himself in his conclusion to speculate about the value of past thought to present-day studies in cognitive science and psychology.<sup>45</sup> The desire to understand the complexity of past systems of thought and its diverse nature as far as possible in its own terms and in its widest context which is evident in recent studies in the history of thought may also be connected to an awareness of the fragmented nature of modern science, and its tolerance of probability and approximation. The prospectus of the European Science Foundation programme being discussed here also justifies the study of the scholastic determinants in the thought of Descartes and Hobbes as residing in a revised vision of two thinkers who are still influential in modern thought. The abandonment of total history in favour of a limited and partial grasp of the past in all its complexity of which historians show themselves to be aware might call to mind Galileo's reminder in his essay on sunspots that we do not know essences but only the properties of things.<sup>46</sup> Theoreticians of history such as Hayden White have reminded us also that narrative causality is not the same as strict physical causality; and others have spoken of the 'extension of the historical agenda' as an effect of academic revisionism, of which an example practised in this programme has been the study not just of ideas and theories but also of non-discursive practices (instrument-making, for example) and practical applications of mathematics.<sup>47</sup>

How are we then to assess the results of the European Science Foundation

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<sup>44</sup> *Discours sur l'origine de l'inégalité parmi les hommes*, ed. Jean-Louis Lecercle, Paris 1971, p. 61: 'un état qui n'existe plus, qui n'a peut-être point existé, qui probablement n'existera jamais, et dont il est pourtant nécessaire d'avoir des notions justes, pour bien juger de notre état présent.'

<sup>45</sup> *Life's form*, pp. 199-202.

<sup>46</sup> 'History and Demonstrations concerning sunspots and their phenomena', in *Discoveries and opinions of Galileo*, trans., Stillman Drake, New York: Doubleday, 1957, p. 97, cited by Rikva Feldhay, 'Religion', in *The Cambridge history of science: early modern science*, p. 744.

<sup>47</sup> Hayden White, *The content of the form: narrative discourse and historical representation*, Baltimore and London: The Johns Hopkins University Press, 1987; Paul Veyne, *Comment on écrit l'histoire*, Paris: Seuil, 1978, 141-56; *Transmitting knowledge: words, images and instruments in early modern Europe* (see above, note 10).

programme? Has it simply confirmed the conjectures set out in *The dynamics of Aristotelian natural philosophy* and the prospectus? Has the argument for the continuity of science been won? Is the scientific revolution a thing of the past?<sup>48</sup> Do we still think of early modern natural philosophers as inmates of ideological or epistemological prisons? Has the thesis of progressive secularisation been discarded? And will all our attempts to find an overarching story end in a congeries of microhistories which bear witness to the fragmented nature of early modern scientific endeavour, dispersed as it was across a wide range of institutions including universities peopled by theorists, academies frequented by gentlemen, and workshops and laboratories run by practitioners of various sorts? These questions are still not settled, and may never be; but it seems that the most modern historiographical trends give precedence to the fragmented over the unitary, to piecemeal progress over dramatic revolution, and to a modified version of constructionism which respects actors' categories and the enterprise of lesser players in the pursuit of progress over the celebration of scientific giants enshrined in positivistic and triumphalist accounts of the past in terms of the present.

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<sup>48</sup> For a range of recent views on the Scientific Revolution by prominent scholars, see 'Focus: thoughts on the Scientific Revolution', *European Review*, 15 (2007), 439-512.