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## The Fragmentation of Renaissance Occultism and the Decline of Magic\*

[*History of Science*, 46 (2008), pp. 1-48.]

### *The touch of cold philosophy?*

At a Christmas dinner party in 1817 an admittedly drunken Charles Lamb berated the famed Isaac Newton as “a Fellow who believed nothing unless it was as clear as the three sides of a triangle.” He and John Keats then agreed that Newton had destroyed all the poetry of the rainbow, by reducing it to a prism.<sup>1</sup>

Lamb and Keats, it seemed, wished Newton in hell, as William Blake had seemed to do earlier in his long poem *Jerusalem* (1804), where he blamed the “cogs tyrannic” of the newly industrializing Britain on the “Water-wheels of Newton” which drove the “Loom of Locke, whose woof rages dire”.<sup>2</sup> Not long after this Christmas dinner party Keats made a public statement about Newton's “cold philosophy” in his poem, *Lamia* (1820):

Do not all charms fly  
At the mere touch of cold philosophy?  
There was an awful rainbow once in heaven:  
We know her woof, her texture; she is given  
In the dull catalogue of common things.  
Philosophy will clip an Angel's wings,  
Conquer all things by rule and line,  
Empty the haunted air, and gnomèd mine -  
Unweave a rainbow...<sup>3</sup>

But the Newton that Lamb, and Keats denounced, and whom Blake despised as a facet of the monstrous “Urizen”,<sup>4</sup> was merely an image of what the previous age,

the “Age of Reason”, thought the great scientist should be like. It was an image of Newton that was the product of Voltaire and other admirers of Newton who saw him as a symbol of what human reason might achieve. The Enlightenment image of Newton, particularly in France, served ideological purposes. For Voltaire Newton's success did not simply derive from his mathematical acuity, his natural philosophy was in some way seen as a testament to the toleration, reason and good sense which prevailed among the English and which also provided them with an enviable political system. The Enlightenment image of Newton had little to do, therefore, with the man himself.<sup>5</sup>

If we take a closer look, however, at what we can reconstruct of Newton's actual beliefs about the nature of the rainbow, it seems hard to resist the feeling that Keats, Lamb and Blake might have been much more inclined to embrace his ideas. Indeed, the very fact that all of us raised in the British tradition believe that there are seven colours in the rainbow—which we try to remember by means of mnemonics like “Richard Of York Gave Battle In Vain”—owes more to Newton's belief in the harmonies of the world than it does to his reputed genius as an experimental scientist (or to the visible appearance of the rainbow—has anyone ever been able to see *seven* colours? Has anyone ever seen indigo in the spectrum?).<sup>6</sup>

Newton's preoccupations become apparent when we look at his own account of his experimental discovery of the nature of the spectrum. In the *Opticks*, first published in 1704, he describes in detail how he came to distinguish the colours in the Rainbow. Having projected the spectrum from a prism on to a piece of paper, he called upon the aid of an assistant:

I held the paper so that the spectrum might fall upon it, whilst an Assistant, whose eyes for distinguishing colours were more critical than mine, did by

Right Lines... drawn cross the Spectrum, note the Confines of the Colours, that is of the red..., of the orange..., of the yellow..., of the green..., of the blue..., of the indico..., and of the violet.... And this Operation being divers times repeated both in the same and in several Papers, I found that the observations agreed well enough with one another, and that the Rectilinear Sides [of the projected spectrum]... were by the said cross Lines divided *after the manner of a Musical Chord*.<sup>7</sup>

It is this last comment which leads us deep into the notion of cosmic harmonies and Newton's belief in ancient Pythagorean wisdom. The seven colours of the rainbow, according to Newton, correspond to the seven notes of the octave, and they correspond so closely that the lines drawn across the spectrum by his supposed assistant are in precisely the same place you would need to bridge a monochord of corresponding length to give you each of the seven notes in the diatonic scale. The importance of this idea for Newton can be inferred, I think, from the fact that it appears in the *Opticks* essentially unchanged from the version which he had presented in his earliest public discussions of the nature of light in one of the papers delivered before the Royal Society of London in the mid-1670s.<sup>8</sup>

The immediate importance of the analogy between light and music for Newton was that it enabled him to answer an anticipated objection to his claim that colours were not, as all earlier natural philosophers insisted, modifications or even corruptions of pure, white, light, but that they were in fact, each one of them, the pure forms of light.<sup>9</sup> If Newton's theory of light was true, it raised an obvious question for his contemporaries: Why might God have made the glorious light of the sun the mere result of a mixture of what, in the aesthetics of the day, were the less glorious kinds of light seen typically through coloured glasses?<sup>10</sup> Right from the outset Newton had a

ready answer. White sunlight should not be seen as a corrupt form of light made by a mixture of purer lights, it should be seen as the result of a superb harmony of the coloured lights shining in unison. Furthermore, it seems safe to say that it must have seemed obvious to Newton that if God had made sunlight in this way, then the colours would show some close similarities to the notes in the octave (and so, of course, there had to be seven). That Newton was predisposed towards this view becomes clear when we look at Newton's first announcement of this idea, in the Optical Lectures which he delivered at Cambridge University from 1670. There is no mention of an assistant in this earlier account, and Newton admits that he could only distinguish five colours. Accordingly, he told his students, he added indigo and orange "in order to divide the image into parts more elegantly proportioned to one another", and to make the analogy with the musical scale possible.<sup>11</sup>

It seems perfectly evident that underlying this aspect of Newton's thought was a belief in the essential truth of the ancient Pythagorean doctrine of cosmic harmony. Pythagoras was renowned as one of the greatest of the ancient sages, and as the first teacher of the concept of cosmic harmonies and of the importance of number and measure for a complete understanding of the world. We have direct evidence of Newton's familiarity with this ancient tradition from a number of remarkable manuscript passages, known as the "Classical scholia", which he wrote for inclusion in an abandoned 2nd edition of the *Principia mathematica*. Here Newton intended to draw upon what was known of ancient Pythagorean doctrine to support his views on gravitational attraction.<sup>12</sup>

Until quite recently, the seriousness of such ideas in Newton's thinking remained controversial. For those commentators who were more positivistically inclined, it was assumed that Newton could not have been serious about such dubious

historical claims, and the fact that they remained in manuscript, withheld from publication, was cited as evidence for his lack of commitment. We now know, however, that these ideas were bound up with a much greater project that Newton was engaged in, namely, his attempted reconstruction of the original religion before it became corrupted in the generations succeeding that of Noah and his sons. There can be no doubt of the seriousness with which Newton pursued these ideas.<sup>13</sup>

It is important to note that the link between the spectrum and the musical scale was not confined to Newton's unpublished manuscripts. It cannot be argued, therefore, that Newton wasn't serious about this idea and thought better of publishing it. As well as announcing it to the Royal Society in the 1670s, he published it in the highly influential *Opticks*. And yet, in spite of the unambiguously clear account of the analogy between the colours of the spectrum and the notes of the diatonic scale in the second of Newton's two great books, it was evidently not an idea which resonated with Enlightenment natural philosophers. Newton's affirmation of Pythagorean cosmic harmonies was soon forgotten and by the early nineteenth century Newtonian science could be disparaged by Keats (evidently speaking for others also) as coldly and unimaginatively unweaving the rainbow. Only in the second half of the twentieth century did scholars begin to correct the Enlightenment image of Newton and to recognize the more magical aspects of his work. The result of this on-going research is to acknowledge Newton as the "last of the magicians", the "last wonder child to whom the Magi could do sincere and appropriate homage".<sup>14</sup> There can be little doubt that he was the last, or among the last. By the time of Newton's death in 1727, the new reformed natural philosophy, which began to emerge in the sixteenth century and which had found its first programmatist in Francis Bacon, was sufficiently well established that its promoters saw it as *sui generis*, and felt no need to acknowledge

its parentage. But Newton was by no means the only natural philosopher who had drawn upon magical traditions. Indeed, Newton's own interest in various magical traditions can best be understood by locating it within a late-Renaissance movement to reform natural philosophy by paying closer attention to various magical or occult traditions.<sup>15</sup>

Although it is now (at last) diminishing, there is still enormous resistance among the more positivist philosophers and historians of science to any suggestion that magic might have been instrumental in the emergence of modern science. It is remarkable, for example, that the authors of two recent books on the role of alchemy in the Scientific Revolution, one introductory the other advanced, both felt the need to justify the claims they were making on behalf of alchemy because of its “associations with magic and the occult”.<sup>16</sup> For the most part, the arguments against the possible influence of magic on science are presented *a priori*, while the historical evidence is simply ignored. So, magic is characterized as irrational and its influence upon a supremely rational pursuit like modern science is easily dismissed as inherently implausible. Similarly, magic is said to be concerned with the *supernatural* and therefore could only be antithetical to mankind’s heroic intellectual endeavour to explain phenomena in entirely *naturalistic* terms.<sup>17</sup> What is particularly unfortunate about this approach is that, by dismissing magic at the outset, it fails to put any effort into understanding the nature and significance of magic in the pre-modern and early modern periods. But this ahistorical approach is intellectual chauvinism of the most arrogant kind, and the result is undoubtedly a diminishing of our understanding of the origins of modern science.<sup>18</sup> To carry on in this vein is to repeat the errors of Sir David Brewster, Isaac Newton’s first biographer. Taking the opportunity to scrutinize

Newton's manuscript remains, Brewster soon came across the huge mass of alchemical manuscripts. His appalled response is well known:

we cannot understand how a mind of such power, and so nobly occupied with the abstractions of geometry, and the study of the material world, could stoop to be even the copyist of the most contemptible alchemical poetry, and the annotator of a work, the obvious production of a fool and a knave.<sup>19</sup>

When seen in the light of Brewster's overwhelming admiration for Newton this is highly significant. An observer might have expected that Brewster would be led by his otherwise slavish veneration for his great forebear to conclude that, if Newton was so interested in alchemy, then there must have been something in it. But no, evidently Brewster's conviction that alchemy was worthless rubbish outweighed even his awe of Newton's genius. This paper, however, is based on the assumption that if many of the leading figures in the Scientific Revolution (undoubtedly among the leading thinkers of their age) drew upon magical traditions it is our job as historians to try to recover what it was that they saw in those traditions. In the process, we will not only learn more about the nature of magic in the Renaissance and in the early modern period, but also about the origins of modern science.

A positivistically inclined reader might be thinking at this point, however, that the fact that Newton's musical analogy as a way of understanding the nature of light has been all but overlooked by succeeding generations of physicists (and so forgotten that even a romantic thinker like Keats was unaware of it) shows that it wasn't of any real significance in the history of science. Knowledge of Newton's belief in such matters is only a historical nicety, helping us to gain a more complete picture of "Newton, the man", but of no relevance to our understanding of the historical development of science. In view of the fact that less than a hundred years after his



death Newton was found guilty of unweaving the rainbow, of removing its awfulness (in the sense of its ability to strike awe) and putting it in the “dull catalogue of common things”, this point perhaps should be conceded. But what about those other aspects of Newton’s physics which were also influenced by magical traditions? We cannot dismiss Newton’s belief in actions at a distance as equally irrelevant to the history of science. Although, in this particular case, it is interesting to note that Newton’s acceptance of *actio in distans*, clear as it is to see in his writings, has nonetheless been vigorously denied, firstly by scientists and then by historians of science.<sup>20</sup>

The concept of *actio in distans* had been rejected by Aristotle and therefore excluded from mainstream natural philosophy from its beginnings in the Latin West in the twelfth century. It was always a prominent feature of the magical tradition, however, being a mainstay of notions of sympathy and antipathy, and therefore appearing in many of the occult arts and sciences, from astrology to alchemy and beyond. It is now generally acknowledged that Newton’s easy acceptance of actions at a distance (manifested most obviously in his concept of gravity, but also in the micro-matter theory discussed in the “Queries” appended to the *Opticks*) derived from his own work in alchemy, where he can be seen to make assumptions about particles operating on one another across a distance.<sup>21</sup> Furthermore, it cannot be denied that these ideas were immensely influential on succeeding generations of chemists and natural philosophers. The history of eighteenth-century natural philosophy, especially in Britain, can be seen in terms of those who accept the Newtonian claim that all phenomena can be explained in terms of attractive and repulsive forces operating between particles, or in terms of those who accept Newton’s idea that all phenomena might be explained by a highly rarefied yet highly transmissive aether, consisting of

particles widely separated as a result of strong repulsive forces operating between the particles.<sup>22</sup>

It seems perfectly clear from Newton's example, therefore, that some aspects of the magical tradition were recognized by early modern thinkers as useful, and by implication, valid or true, while other aspects of the tradition were either ignored or rejected, and were by implication held to be invalid or false. The main aim of this article is to demonstrate that this was not just a feature of magical ideas as far as Newton was concerned, but was in fact the more general fate of the magical tradition. Some aspects of the tradition were taken up by practitioners and became absorbed into reformed versions of natural philosophy, while other aspects of the tradition were rejected.

Indeed, it seems perfectly clear that something recognizably like modern science first emerged as a direct result of the absorption of various aspects of the magical tradition into traditional contemplative natural philosophy. Both the experimental method, and the concern that knowledge of the natural world should be put to use for the benefit of mankind, can be seen to have been long-established aspects of the magical tradition which came increasingly to be embraced by students of nature, who thereby turned traditional natural philosophy into one or other of the so-called new philosophies of the early modern period.<sup>23</sup> It hardly seems necessary to repeat the arguments in support of this claim here. This does not mean, however, that there is nothing more to be said. If it is true that major aspects of the magical tradition became absorbed into what we might call (if we are allowed a bit of anachronistic leeway) modern science, then this has implications for claims that have been made about a perceived decline of magic at the end of the seventeenth century. The 'decline' in question, of course, is the decline of magic as a topic for serious scholarly

investigation and discussion. While magical ideas continued to flourish in popular culture, they declined dramatically among the highly educated elite, and came to be regarded as well beyond the intellectual pale. The reasons for this are undoubtedly manifold, and a number of reasons for the decline have already been discussed, most notably, of course, in Keith Thomas's *Religion and the Decline of Magic*.<sup>24</sup> The aim of this paper is to suggest another major reason for the decline of magic; a reason which has not been discussed before, and which has significant implications for our understanding of early modern intellectual history.

In the rest of this paper, therefore, I want to offer a new perspective to add to previous attempts to explain the so-called decline of magic. I suggest that there was a *fragmentation* of the occult arts and sciences during the Renaissance and early modern periods, as some aspects of the magic tradition became appropriated into the new philosophy, or new science. To a large extent it was the in-put from magic that made the new philosophies what they were, not only with regard to the experimental method and the new ethos that natural knowledge should be pragmatically useful, but also with regard to the substantive content of those new philosophies. At the same time, however, other aspects of the magical tradition were firmly rejected. These historical changes are perhaps best understood in terms of what sociologists of science have called 'boundary work', the process of demarcating supposed legitimate and valid procedures and presuppositions in establishing natural knowledge from those that are deemed invalid and illegitimate.<sup>25</sup> From the Renaissance through the period known as the Scientific Revolution there was a complete rearrangement of the boundaries of what was magic or occult and what was not, which in turn involved a redrawing of the boundaries which determined what was natural philosophy and what

was not. Furthermore, it is my contention that this led to a decline in the fortunes (among orthodox thinkers at least) of what was left behind in the realms of magic.

My account also helps us to see, therefore, what is in fact a major historical and historiographical irony. The reason why positivistically inclined commentators on the development of science have refused to acknowledge the relevance of magic to the history of science is because they mistake the rejected left-overs of the magical tradition—the pathetic rump of the tradition remaining after early modern natural philosophers had taken what they wanted from it—as the whole of the tradition. I said earlier that such historians, like Brewster confronted with Newton’s alchemy, refuse to make any attempt to understand the nature of the magical tradition. Just as Brewster, writing in the 1850s, knew the current reputation of alchemy and didn’t try to assess its reputation in Newton’s day, so certain modern commentators of science have relied upon their current understanding of what magic is (and by implication always has been), and have refused to accept the claims of other historians that magic was once so different that, properly understood, it is easy to see how it might have, and indeed did, influence the development of modern science. The currently prevailing conception of the magical tradition began to be forged in the eighteenth century and has continued into our own times, no less than the image of Newton as “a Fellow who believed nothing unless it was as clear as the three sides of a triangle”, began to be forged in the Enlightenment and has been reinforced ever since.<sup>26</sup>

Before proceeding it is important to note that I frequently talk here of a magical tradition as if there was indeed a unified tradition. This is in fact almost certainly not the case, and I am fully aware that I am imposing a unity on numerous different aspects of occult thinking in order to then say this unity is fragmented! I do this simply to make my overall argument clear and avoid tedious circumlocutions at

every turn. My argument by no means relies on the false claim that there was a unified tradition; on the contrary, I am arguing here that, during the Renaissance and in some cases persisting through to the late seventeenth century, various different ways of understanding natural phenomena which were excluded from mainstream scholastic natural philosophy, and which were all to some extent based on occult or magical assumptions, began to be considered more seriously by the learned, and were considered as possible ways of reforming the traditional natural philosophy which came to be seen as increasingly inadequate for a proper understanding of the natural world. My claim is not that the up-shot of these fresh looks at occult arts or sciences led natural philosophers to conclude that there was a unified tradition here which they then proceeded to break up. I simply wish to assert that some aspects of this diverse set of arts and sciences were seen as useful for contemporary reformist ambitions and were absorbed into natural philosophy, completely transforming that philosophy in the process, while other aspects were rejected. The fragmentation of Renaissance occultism should not be seen as similar to the fragmentation of western Christianity after the Reformation, therefore, because there was no previous occult tradition comparable in its monolithic nature to Roman Catholicism. My title should perhaps have indicated a discussion of the selective take-up of various occult arts and sciences and the rejection of others, but I hope the more succinct phrasing of the first part of my title is not too misleading. It fits in better, anyway, with the historiographically commonplace (and equally misleading) talk of the ‘decline of magic’.<sup>27</sup>

Having said that, let us begin by taking as broad an overview as we can of the nature of what I have called in my title ‘Renaissance occultism’ and its would-be practitioners.

*The Nature of 'Magic' and of 'Magicians'*

One major reason for the prevailing mistaken conception (by positivist historians and others) of the nature of magic in the Renaissance is the lack of any understanding of what was known as *natural* magic. Lack of awareness of the natural magic tradition is due to the fact that it was to a large extent completely absorbed into what we now think of as science, while other, lesser, aspects of the tradition have remained in what should be regarded as merely a rump of the magical tradition—what was left over after parts of the tradition had been absorbed into natural philosophy. Today, we tend to identify magic with the supernatural (if we leave aside the stage trickery of ‘show-business’ magic), but in the period we are looking at, to describe an event or a phenomenon as supernatural was to say that it had been brought about miraculously by God—only God was above nature, and only God could perform a supernatural act.<sup>28</sup> Magic, by contrast, exploited the *natural* properties of things and the successful magician was believed to be highly knowledgeable about the different occult qualities of things. As Giovanni Battista Della Porta wrote:

Magic is nothing else but the knowledge of the whole course of Nature. For whilst we consider the Heavens, the Stars, the Elements, how they are moved, and how they are changed, by this means we find out the hidden secrecies of living creatures, of plants, of metals, and of their generation and corruption; so that this whole science seems merely to depend upon the view of Nature...

This Art, I say, is full of much vertue, of many secret mysteries; it openeth unto us the properties and qualities of hidden things, and the knowledge of the whole course of Nature; and it teacheth us by the agreement and the disagreement of things, either so to sunder them, or else to lay them so together by the mutual and fit applying of one thing to another, as thereby we

do strange works, such as the vulgar sort call miracles, and such as men can neither well conceive, nor sufficiently admire... Wherefore, as many of you as come to behold Magick, must be persuaded that the works of Magick are nothing else but the works of Nature, whose dutiful hand-maid magick is.<sup>29</sup>

This definition appears in the most popular textbook of magic of its day, simply titled *Magia naturalis* (quoted from London edition of 1658, but first published in 1589), but the same claims about the nature of magic are repeated time and again. Cornelius Agrippa, a leading Renaissance contributor to the magical tradition, insisted that “magicians are careful explorers of nature only directing what nature has formerly prepared, uniting actives to passives and often succeeding in anticipating results so that these things are popularly held to be miracles when they are really no more than anticipations of natural operations”.<sup>30</sup>

The major assumption of natural magic, then, was that all bodies have occult qualities which make them capable of acting upon other bodies in various ways, though in many cases the working of these occult qualities are supposed to be highly specific. The main method of putting magical knowledge to use, therefore, is to bring together a body known to have a specific action and the body upon which it is known to act, or else to separate such reactants for a negative effect. This is what Della Porta meant by sundering or laying together things in accordance with their “agreement and disagreement”, and what Agrippa meant by “uniting actives to passives”. This doctrine made a major impression on the great reformer of natural philosophy, Francis Bacon, who stated it in the fourth Aphorism of his influential *New Organon*: “Towards the effecting of works, all that man can do is put together or part asunder natural bodies. The rest is done by nature working within.”<sup>31</sup> Such occult interactions were often described in terms of sympathies and antipathies between bodies, a

notoriously magical way of talking which nevertheless was employed with minor changes by such leading exponents of the new philosophy as Robert Hooke, who spoke of congruities and incongruities between bodies, and Isaac Newton, who explained certain chemical phenomena in terms of principles of sociability and unsociability.<sup>32</sup>

When compared with natural magic other aspects of the tradition, aspects which today are all too often held to be characterizing features of magic, were distinctly subordinate. The truly learned magus was held to be a man (it was always a man of course<sup>33</sup>) with a vast knowledge of “how to effect things worthy of the highest admiration... by the mutual application of natural actives and passives”.<sup>34</sup> The great magician, in other words, knew by experience many of the operations of the occult qualities of things and knew how to put that knowledge to use. Lesser magicians, however, might have to resort to one or other of two alternative aspects of the tradition, as a substitute for their lack of knowledge. Both of these aspects of the magical tradition were seen as means of cutting corners, or of taking a short cut, to the knowledge of the occult qualities which the real magus would learn by experience (in principle at least—though in practice more usually by relying on magical lore, increasingly *printed* magical lore).<sup>35</sup>

I am referring here to sorcery (which includes necromancy, theurgy, witchcraft and all other arts of summoning spiritual beings), and semeiology or symbolic magic (which relies upon the power of signs, words and other symbols, and includes numerology, gematria, spellbinding, incantation and so on). These are the very things which many think of today as definitive of magic, but this is largely thanks to the re-drawing of boundaries which took place in the early modern period. In the pre-modern period demonology and symbolic magic were seen primarily as subordinate to



natural magic. An important element of symbolic magic, for example, involved the reading of the ‘signatures’ of things. It was supposed that God, at the Creation, had left physical clues about the secret workings of things, these were the signatures. So, as one commentator wrote: “besides the manifest and occult qualities of plants, from which their uses may be inferred, [Nature] has marked those which are most useful to us with certain signs and characters”.<sup>36</sup> God and Nature, after all, did nothing in vain, and so there must be a reason for every characteristic feature that a thing might have. A favourite example among historians is the walnut: crack open the shell and the flesh of the walnut resembles the human brain sitting in the skull, being divided down the middle and having a surface made up of convolutions. What else could this be but a sign from God that the walnut bears some relationship to the human head or brain? The usual assumption was that the signature indicated some curative power, and so walnuts were assumed to offer a cure, perhaps for headaches, or for mental disturbance. Needless to say, precise determination of the efficacy of walnuts would require empirical research of a trial and error kind. In this respect at least, then, symbolic magic can be seen as a short-cut to the knowledge of occult qualities required by the natural magician.<sup>37</sup>

The link between natural magic and the signatures of things is easy to see, but to link *sorcery* to natural magic seems, on the face of it, bizarre in the extreme. Natural magic, as we've seen, in spite of its name, seems rather close to what we think of as science. It depends, after all, on the assumption that particular bodies have a power of interacting with others to create new bodies, or have a power of easing pain, curing specific diseases, and so on—assumptions which are no different from those of modern chemistry or pharmacology. Demonology, by contrast, seems to us to be completely divorced from any naturalistic conceptions. There is a lesson to be learned

here, however, about the astonishing flexibility of our cultural categories, and of our ability to redefine conceptual or disciplinary boundaries.

Surprising though it may seem, sorcery too was seen as little more than a way of avoiding the painstaking gathering of knowledge of occult qualities from experience. If we wish to understand this we must once again be aware of the shift in meaning of the notion of the 'supernatural'. From our perspective it seems a reasonable assumption that for pre-modern thinkers demons were capable of performing supernatural acts to bring about some miraculous event. This fits *our* assumptions about demons. *Our assumptions, however, are historically misguided.* It is something of an irony that present-day notions of demons with comic-book superpowers (as seen on TV in *Buffy the vampire slayer* and other such shows) are the products of secular imaginations. In the pre-modern and early modern intellectual cosmology only God could do supernatural things. Demons, even the Devil himself, were God's creatures and as such were subject to natural law just like the rest of us.<sup>38</sup> As John Cotta wrote in *The triall of witch-craft* (1616): "Nature is nothing else but the ordinary power of God in all things created, among which the Divell being a creature, is contained, and therefore subject to that universal power".<sup>39</sup> In so far as the Devil *could* perform marvelous feats it was only by virtue of the fact that he was a consummate natural magician. The Devil knew the occult qualities of things, and how to apply appropriate actives to passives to accomplish whatever might be required. William Perkins put it rather well in his *Discourse of the damned art of witch-craft* (1618):

[The Devil has] exquisite knowledge of all natural things, as of the influences of the starres, the constitutions of men and other creatures, the kinds, vertues, and operation of plantes, rootes, hearbes, stones etc., which knowledge of his

goeth many degrees beyond the skill of all men, yea even those that are most excellent in this kind, as Philosophers and Physicians are.<sup>40</sup>

King James VI of Scotland likewise believed that the Devil was “farre cunningner then man in the knowledge of all the occult proprieties of nature”.<sup>41</sup> Accordingly, if a would-be practitioner of natural magic was at a loss about how to accomplish a particular outcome he might indulge in necromancy to summon one of the dead, on the assumption that the dead person might know how to bring about the desired end.<sup>42</sup> The more ambitious magus, or one with a bigger problem might similarly decide to summon a demon, or even the Devil himself. It is important to note, however, that if the Devil did succeed in performing what the magus wanted it would be because, as William Perkins wrote:

in nature there be some properties, causes, and effects... most familiar unto him [the Devil], because in themselves they be no wonders, but only mysteries and secrets, the vertue and effect whereof he hath sometime observed since his creation.<sup>43</sup>

The Devil, in other words, does these things in the same way that the natural magician does, but with greater success because of his greater experience—the Devil, after all, has been around for a very long time. The vulgar might think that the Devil and the magus are capable of producing miracles, but, as Cornelius Agrippa insisted, both merely anticipate and exploit natural operations.<sup>44</sup> “Demons operate nothing”, wrote Francesco Giuntini, “except by natural application of active forces to the appropriate and proportionate passive objects, which is the work of nature.”<sup>45</sup>

So, although the logic of symbolic magic and the logic of demonology were closely linked to the logic of natural magic in the pre-modern period, by the end of the sixteenth century a re-alignment was under way. By the end of the seventeenth

century major aspects of the natural magic tradition had been appropriated by the new philosophies or redefined in order to fit more easily with the new kinds of naturalism. But Symbolic magic, demonology and some aspects of natural magic, such as astrology, and the chrysopoeic aspects of alchemy, were left aside in what was effectively a new, differently defined, category of magic.

An important aspect of the re-designation of natural magic as a set of assumptions that could be more fruitfully exploited in natural philosophy was, effectively, a denial that natural magic was magic. Thanks principally to the power of the Church, magic had always had what today would be called a 'bad press'. As if the escapades of frauds and charlatans claiming to be alchemists, astrologers, and magicians were not enough to damage the reputation of magic, the Roman Catholic Church tended to emphasize its demonological aspects in order to present it as dangerous and irreligious. It seems clear that the Church wanted to avoid confusion between the miraculous and the kind of marvellous things which were achievable through natural though occult means. Natural magic seemed to suggest, to the uneducated at least, that miraculous things could be accomplished by laymen without supernatural aid. This implicit threat to the authority of the Church could be neatly turned around by insisting that all magic was accomplished by demonic aid, and so condemning it in the most vigorous terms. For the Church, every magus was a Doctor Faustus (and during the witch-crazes every village 'cunning man' or more especially 'cunning woman' was accused of deriving their knowledge not from local lore but directly from Satan).<sup>46</sup> It is this attitude of the Church which underlies the comments we have already seen, in which Della Porta, Agrippa, and others insist that magic is merely the study of nature and so, by implication, no more dangerous to the faith than natural philosophy.

It is hardly surprising, therefore, that although we come across many reputed magicians in the historical record, we do not come across many who declare *themselves* to be magicians; on the contrary, they usually deny it. Nobody was reputed a greater magician than Roger Bacon and yet Bacon himself vigorously denied that he did anything by magic. If we were to take Bacon, and other magicians in denial, at their word, however, we might have to conclude that there was no such thing as a magical tradition, and that nobody ever was a magician. In a sense the latter is true, because there never was a Merlin, or a Faust, there were only mathematicians, alchemists, cabbalists, natural philosophers of a more mystical bent than usual, humanist scholars enthralled by Neoplatonic theurgy, and so forth.<sup>47</sup> But we need to bear in mind the historical actors' categories, not our own. From the point of view of his contemporaries, Roger Bacon was, as the late George Molland pointed out, "a full-blooded magician", and in Molland's estimation this was hardly surprising since, in spite of his protestations to the contrary, Bacon "went some way to meriting his later classification as a magician".<sup>48</sup>

As a result of religious condemnation of magic, then, it wasn't possible simply to appropriate occult traditions in an open way into natural philosophy. Accordingly, an important aspect of the absorption of natural magic into reformed versions of natural philosophy was the defense of those past thinkers who were alleged to be magicians from all charges that they were magicians. Again, as George Molland has pointed out, reputed medieval magicians like Al-Kindi, Albertus Magnus, Roger Bacon, Arnald of Villanova and Michael Scot were transformed in early modern scholarly literature from magicians into heroes of experimental science. The major contribution to this new enterprise was Gabriel Naudé's *Apologie pour tous les Grands Personages qui ont esté faussement soupçonnez de Magie* (Paris, 1625), but

John Dee, evidently defended Roger Bacon, in a work now lost, from charges of sorcery.<sup>49</sup> Similarly, Robert Hooke later took it upon himself to defend Dee. Having acquired increased notoriety from a newly published account of his supposed converse with various angels, Dee was defended by Hooke as a cryptographer rather than a sorcerer. According to Hooke, these angelic conversations were in fact a “concealed History of Nature and Art”. In taking this line, Hooke was simply re-using the same defense which had been used to protect the reputation of Johannes Trithemius—another magus who reported his conversations with angels, but which were later claimed to be merely exercises in cryptography (the point of the exercises being to find what was really being said under the guise of these conversations with angels).<sup>50</sup>

Other exploiters of the magical tradition chose to obscure their indebtedness to the tradition, or to confuse contemporaries as to their commitment to magic. Francis Bacon vigorously criticised magic even as he appropriated many of its precepts and doctrines.<sup>51</sup> Cornelius Agrippa made the status of his *De occulta philosophia* (Cologne, 1533) somewhat ambiguous by publishing what looked like a retraction of it three years before publishing the work itself (although the supposed retraction, *De incertitudine et vanitate scientiarum*, has recently been shown to be far from straightforward).<sup>52</sup> Isaac Newton would never have declared himself to be the last of the magi, but it is significant that he responded to Leibniz’s charge that his principle of gravity was a “scholastic occult quality” not by denying that it was occult, but by denying that it was ‘scholastic’, which is what he meant by rejecting occult qualities which were supposed to depend upon specific forms:

These Principles [gravity and other “active principles” in matter] I consider, not as occult Qualities, supposed to result from the specifick Forms of Things,

but as general Laws of Nature, by which the Things themselves are form'd; their Truth appearing to us by Phaenomena, though their Causes be not yet discover'd. For these are manifest Qualities, and their Causes only are occult.<sup>53</sup>

Although Newton wants to rhetorically present the obvious fact that bodies fall to the ground as 'manifest', gravity was never a manifest quality in the scholastic sense, if its causes were occult then it was occult. Newton knew this, just as he knew that the actions at a distance he invoked in the Queries at the end of the *Opticks*, and in the Preface to the *Principia*, were as much a part of the magical tradition as the alchemy he had so fervently pursued.<sup>54</sup>

Neither silence about magical influence, nor even explicit denial of magic, should be taken as evidence that magical traditions did not play a role in the origins of modern science. We need to be constantly aware of the process which sociologists of science refer to as 'boundary-drawing'. As we shall see, early modern thinkers re-constituted symbolic magic as beyond the intellectual pale, for example, while continuing to accept natural magic; others reasserted the untenability of sorcery (whether on sceptical or religious grounds<sup>55</sup>), while claiming other facets of the magical tradition as defining aspects of natural philosophy. Those positivistic historians and philosophers of science who have regarded magic as antithetical to science have made the mistake, in my view, of neglecting such changes in what constituted magic. They have tended to assume that magic in the early modern period was essentially the same as it is now. In fact, magic has changed radically. Chiefly because significant parts of the original tradition have been absorbed into natural philosophy, and redefined by the historical actors themselves (all too conscious of religious opposition to magic) as though they were always aspects of natural

philosophy or other legitimate attempts to understand the natural world.<sup>56</sup> I disagree, therefore, with the suggestion of Frank L. Borchardt that, sooner or later, magicians themselves expressed a “disappointment in magic”, recognising that it led inexorably to demonolatry, and repudiated it as they all turned back to religious orthodoxy. It seems to me that the story is rather one of negotiating with the faith, their own as much as that of leading Churchmen, and appropriating certain aspects of magic into their own philosophical systems, while leaving the more religiously dangerous aspects to remain in what became an increasingly demonologically defined (as opposed to the former more *naturally* defined) magic.<sup>57</sup> One of the major reasons why the influence of magic on science (if we can speak anachronistically for the sake of a historiographical argument) has been denied is precisely because those aspects of magic which clearly did influence science are now simply regarded as part of the history of science, and so no longer recognized to be part of the history of magic. Meanwhile, those aspects of magic which were not absorbed into science, and to a large extent were seen in the early modern period as antithetical to a proper understanding of natural phenomena, have come to be regarded as entirely representative of magic, not just as it was after the end of the seventeenth century, but as it was throughout the whole of its career through Western culture. This is simply a very misleading mistake.

*Clipping Angels' Wings: The Changing Status of Demonology*

The separation of natural magic from demonic magic is such an important part of this story that is worth considering the background in more detail. We have suggested that natural magic and demonology were always closely linked, so why didn't these linkages persist after the absorption of various aspects of the magical tradition into the



new philosophies? After all, we do know that the various new philosophies continued to be closely affiliated to religion,<sup>58</sup> and so we might expect to see the precepts of demonology being carried over into the new philosophies.<sup>59</sup> As Stuart Clark has shown, however, it is possible to see why demonology was separated from both natural magic and natural philosophy in the early modern period, in spite of (or maybe even because of) the otherwise friendly relations between science and religion. In what follows, I rely entirely upon Clark's analysis.

The sixteenth century was, of course, a period of intense religious turmoil, not only by virtue of the factionalism of the Reformation, but also as a result of major efforts (not unconnected) to increase the levels of spirituality and religious observance among the laity. It was almost inevitable in this atmosphere that the detailed scrutiny of what occult qualities can and cannot do in natural philosophy was bound to have repercussions in demonology. Particularly as this was also the age of the witch craze.<sup>60</sup>

Since accusations of witchcraft always began with notions of occult influence—the evil eye, or laying a curse or some such—it became important for the demonologist to be able to distinguish between what was a natural effect and what was not. If a villager was able to make a neighbour's milk-cow go dry by natural, even though occult, means, the Church, in principle at least, would not be so concerned about it (because it could be regarded as simply a criminal matter, equivalent to an assault, and a matter for the secular courts). The Church's main concern was with those who were believed to have made a pact, a bargain, with the Devil. Accordingly, it was important to be able to distinguish what could be accomplished without demonic aid, from what could not. The decision as to whether a particular malfeasance was brought about by natural or unnatural means depended of course

upon what could be said to be natural (even though occult). This does not mean, however, that demonologists had now departed with tradition and orthodoxy and had decided that the Devil could, after all, perform supernatural phenomena (remember, we saw earlier that the pre-modern view was that the Devil could not do anything supernatural but could only exploit his knowledge of natural magic). No, the unanimous assumption was still that the Devil could only perform his deeds by natural means, but that he was so clever at exploiting occult qualities, that he could deceive onlookers into mistaking just how a particular accomplishment was achieved. The witch might have thought that covering herself with an ointment made from the fat of birds enabled her to fly, but in fact the Devil enabled her to fly by some other natural means, or more likely, simply used natural means to give the witch the illusion of flying (the ointment, in other words, was not an anti-gravity substance, but merely a hallucinogen). In this case, following Thomas Aquinas, the theologian will argue that the ointment is effectively a sign of the witch's compact with the Devil.<sup>61</sup>

So, natural philosophers and theologians were both concerned to decide what was natural and what was not. Needless to say, there were numerous disputes. The upshot, in demonology, was that if an effect was brought about by spurious means, that is to say, by means which could not be shown to bring about that effect in a natural way, then the conclusion was that the devil was affecting the outcome, and so the human agent was guilty of a satanic pact. A witch charged with poisoning a neighbour who said she had administered the poison by contaminating his well, would be considered differently from one who said she had walked through his wall and dropped the poison into his mouth as he slept. The Devil, being a spirit, can walk through walls, but he cannot arrange for a human being to walk through a wall. He

can, however, make the witch *believe* she has walked through a wall, but if she did believe that then she is guilty of colluding with the Devil in some way.

This aspect of demonology was not confined to witch trials, nor to those occasions when an accused was supposedly successful in bringing about a magical outcome. It is easy to see that for the Churchman concerned to improve the general spirituality of his flock, even a *false* belief that a charm, or a particular incantation, or even a particular herb, will bring about a desired outcome, is a sign of lack of trust in God. Popular beliefs about the efficacy of various techniques and rituals for bringing about good health or good fortune, for foretelling the future, or for making the right decision, ignored the divine aspect of Providence and all that went with it (such as an awareness of the need for prayer and repentance). It seemed to the theologian to be at best an idolatry, placing faith in God's creatures rather than God himself, and at worst to be a form of paying homage to the Devil—since these procedures are not thought to work by natural means, the persons who perform them must expect the Devil to intercede for them.<sup>62</sup>

In this way, then, demonology extended itself to embrace the study of superstition. But superstition at this time was regarded by Churchmen with great seriousness; like witchcraft it was seen as “religion's opposite”, and it therefore became of the utmost importance to eradicate or to suppress the superstitious magic of popular culture. We can't pursue here the various ways in which the Church tried (often unsuccessfully) to eradicate popular magical beliefs, but it is important for us to note that one essential ingredient in all such efforts was an insistence upon the spuriousness of the causal links between the supposed magical procedure and the desired outcome. Churchmen were concerned, therefore, first of all to understand the *real* causal linkages available in nature (even if they may be occult) and secondly to

use that knowledge to draw a clear distinction between legitimate natural philosophy and illicit magic. The category of magic was again redefined in this process; the intellectual boundaries around it redrawn. For Churchmen, magic became interchangeable with witchcraft and superstition, all being seen as attempts to use the power of the devil to bring about a desired outcome.<sup>63</sup> The appalling enthusiasm with which Churchmen redefined magic—changing it from a knowledge of the natural powers of things to a commerce with the Devil—provided the intellectual underpinning for the European witch-crazes.<sup>64</sup> Such religious excesses made it all the more important for those natural philosophers who recognized the usefulness of the magical tradition to extract what they needed from that tradition and to incorporate it into the safe intellectual haven of natural philosophy, denying that it had anything to do with magic. Here again, we can see that what was left behind by the new philosophers, what was *not* taken up by them and incorporated into natural philosophy, was in fact just a patchwork of the earlier magical tradition, but it soon came to be seen as the full picture.

It can be seen, then, that the Churches were vigorously re-asserting what had always been their dominant view, that all magic is sorcery, at the same time that natural philosophers were absorbing much of the tradition of natural magic into their new philosophies. The result was a major shift in perceptions of what was magic and what was not. But such a sea-change in the categorization of magic did not take place at the throwing of a switch. Clearly it was a rather more piecemeal, and complex process than I've been able to indicate here. Throughout the second half of the seventeenth century, on the eve of the Enlightenment, it was still possible for a natural philosopher like Boyle, or Newton (or any number of others) to draw upon the old natural magic tradition to provide them with theories of matter, or methodological

justifications for occultist explanations, and they can clearly be seen to have done so. It was no longer possible, however, for them to speak meaningfully about the importance of the magical tradition in their work: even by then such a pronouncement would have been misunderstood. Here, for example, we can discern a clear difference between Boyle and Newton on the one hand, and Francis Bacon on the other. Bacon, writing at the beginning of the century, could explicitly discuss the validity of magic, or simply invoke precepts which he overtly affirmed to be appropriated from the magical tradition, but Boyle and Newton never did this.

This is not to say that Boyle, Newton and others at the end of the seventeenth century would have *self-consciously* kept quiet about their indebtedness to the magical tradition—using it, but deliberately avoiding any acknowledgement that they were using it for fear of the Church. That’s not how the social process of re-defining disciplinary boundaries works. Participating in the boundary-drawing process themselves, Boyle and his contemporaries almost certainly would have simply denied magical influence (as Roger Bacon had done centuries before). Boyle himself, we know, was highly troubled in his conscience by his attempts to succeed at the old alchemical dream of transmuting lead into gold. Shortly before his death Boyle consulted his close friend Gilbert Burnet, Bishop of Salisbury, for advice and reassurance on some matters that troubled his conscience. Burnet took a record of the discussion and Michael Hunter has recently analyzed these notes.<sup>65</sup> It is important to realize that the discussion between Boyle and Burnet does not involve concerns about the matter theory of alchemy, nor are there any doubts that alchemical transmutation is possible. What does concern Boyle, however, is the fact that every successful transmutation which Boyle knew about, including one he allegedly performed himself, were brought about by the use of a ready-made powder which came from a

mysterious source. If such an alchemical powder had been made by Boyle himself, he could be sure that it was produced by natural means. There was an obvious danger however if the ready-made powder was simply given to him (as indeed it was)—the powder might not be a natural cause of transmutation but merely a sign from the Devil. Perhaps alchemical transmutation has only ever succeeded with the help of the Devil, whom even Boyle unwittingly invoked when he used the powder given to him by a stranger.<sup>66</sup>

Hunter provides us with another example. This time told by John Flamsteed, first Astronomer Royal. A local Greenwich washerwoman who had had a parcel of linen stolen asked Flamsteed if he could tell her where it was by divination (note that she saw no distinction between an astronomer and an astrologer). Flamsteed was evidently in a flippant mood and he drew circles and squares at his desk before telling her where she might find the linen. You can no doubt guess what happened. She *did* find the linen exactly where Flamsteed said it would be. She returned to the Royal Observatory to give Flamsteed half a crown, but Flamsteed was horrified:

Good woman, I am heartily glad you have found your Linen; but I assure you I know nothing of it, and intended only to joke with you... But I see the Devil has in mind I should deal with him: I am determined I will not. Never come or send any one to me any more, on such Occasions, for I will never attempt such an Affair again while I live.<sup>67</sup>

It seems clear from these stories that the new concept of magic, as the locus of activity for the Devil, was gaining ground with natural philosophers as well as theologians. It does not follow, however, that these natural philosophers rejected the possibility of transmuting lead into gold by natural means, much less all the other occult

phenomena which until recently had been routinely seen as part of the natural magical tradition.

If what was left of magic became increasingly identified with superstition throughout the seventeenth century, it was forced to undergo another shift in the eighteenth century. The intellectual leaders of the succeeding age, the would-be “Age of Reason”, had their own agenda, and their own very different reasons for dismissing all superstition, and in their case, all serious talk of demons. In that further shift, during the Enlightenment, the old idea that demons (thanks to the long experience they gained as immortals) were merely adepts of natural magic was completely lost. The secularists of the Enlightenment tended on the one hand to imagine that those benighted individuals who believed in demons believed them to be supernatural beings, while on the other hand they were hardly aware of the tradition of natural magic, since much of it had by then become absorbed into the new philosophies.

#### *The Selective Absorption of Aspects of the Magical Tradition*

The foregoing should not be taken to mean that natural philosophers simply decided in a deliberate way to look into the magical tradition to see if there was anything they could incorporate into their natural philosophies. This was no more the case than that natural philosophers in the sixteenth century deliberately decided to go and see what artisans and craftsmen were doing, on the chance there might be something they could use. Nevertheless, it is just as true to say that natural philosophers began to become more and more familiar with occult arts and sciences as it is to say that scholars and craftsmen began to interact during the Renaissance as they never had before.<sup>68</sup> In some cases, of course, reformers did extol the deliberate appropriation of knowledge from craft or magical traditions, and no doubt some of their readers did follow suit.

Certainly, Juan Luis Vives did urge his scholarly readers in 1531 “to enter into shops and factories, and to ask questions from craftsmen, and to get to know about the details of their work”; and Francis Bacon urged readers of his *Novum organum* (1620) to systematically search through magical lore,

for although such things lie buried deep beneath a mass of falsehood and fable, yet they should be looked into... for it may be that in some of them natural operations lie at the bottom; as in fascination, strengthening of the imagination, sympathy of things at a distance, transmission of impressions from spirit to spirit no less than from body to body and the like.<sup>69</sup>

For the most part, however, what we are dealing with is a diffuse movement, throughout Europe and spread over the sixteenth and seventeenth centuries, of thinkers adopting, or adapting, theories, assumptions, and techniques which previously would have been seen as too occult or too susceptible to the charge of being demonic, into what came to be accepted as the new philosophy. Again, different aspects of this diffuse movement, need to be understood differently. William Gilbert, who developed an explanation of the perpetual movement of the Earth (demanded by Copernican theory) based on the occult properties of magnets, may not have been looking for a way to explain the motion of the Earth, but realized he could offer an explanation after reading Maricourt’s *Epistle on the Magnet*. Robert Boyle did not turn to alchemy as a result of his dissatisfaction with Cartesian mechanical philosophy—he already was an alchemist, and may well have recognized inadequacies in Cartesianism precisely because of his alchemical knowledge.<sup>70</sup> In lots of different ways magical ideas became incorporated into the mainstream of philosophical thought, but only in a few cases was this the result of a self-conscious effort to plunder magical traditions.



The precise way in which different areas of the occult arts and sciences were taken up by natural philosophers can be seen, therefore, to be complex and affected by many historical contingencies. It is not possible to provide a model which reveals how the occult was absorbed into mainstream philosophy because each case was very different. The process was not systematic, and may not even have been fully comprehensive, embracing every aspect of the occult, but it was undeniably extensive. What follows in this section is not intended to be a complete account, but merely a preliminary attempt to show how aspects of at least some of the occult sciences came to be incorporated into the new philosophies of the early modern period, while others were considered for inclusion but ultimately rejected.

So-called mathematical magic, for example, was concerned with the demonstration of what could be accomplished by machinery. Machines, after all, were intended to perform marvellous feats which could not be done by normal means, and they did so in ways that were by no means manifest to a casual observer. Their operations were, therefore, by definition *occult*. In part this can be seen as an example of Arthur C. Clarke's 'law', that "any sufficiently advanced technology is indistinguishable from magic". But it would be a mistake to assume that this meant that Renaissance thinkers believed that machinery was worked by hidden demons.<sup>71</sup> The ill-educated were superstitious, of course, and sometimes might well have thought this way, but among the educated it was perfectly well known that machines worked by means of cunningly arranged mechanical contrivances. Consider, for example, Salluste du Bartas's description of the "iron fly", allegedly built by the mathematician Regiomontanus and capable of flying around a room:

O devine wit, that in the narrow wombe

Of a small Flie, could finde sufficient roome

For all those springs, wheels, counterpoise, & chaines,  
Which stood in stead of life, and spurre, and raines.<sup>72</sup>

This iron fly would still have been held to work by occult means. Because the mechanical arrangements which “stood in stead of life” were hidden, and their mode of operation was not obvious to the senses, and moreover could not be explained in the terms of Aristotelian natural philosophy, they were regarded as occult powers, analogous to the workings of occult qualities in natural bodies.<sup>73</sup>

The mathematisation of the world picture has always been regarded as an important element in the Scientific Revolution, but scholarly analysis of this crucial historical process has failed to pay sufficient attention to the undeniable associations between mathematics and magic in the Renaissance. Historians of mathematics have looked to humanists, astronomers, Jesuit mathematicians, and mathematical practitioners of the more pragmatic kind (artillerymen, surveyors, merchant book-keepers, and engineers of various kinds), but have largely ignored those Renaissance intellectuals who were more concerned with the magic of mathematics.<sup>74</sup> This is undoubtedly another result of the positivist tendencies among historians of science, tending to dismiss anything which smacks of magic. Where magical mathematics has been discussed it has been seen purely as an aspect of Renaissance culture, and its possible relevance to the subsequent development of mathematics is left unconsidered. J. Peter Zetterberg, for example, takes it for granted that there was something called ‘the mathematicks’ which was unfortunately all too often *mistaken* for magic. It evidently never occurred to him that mathematics could have been, as indeed it was, regarded by pre-modern thinkers as a major part of the magical tradition.<sup>75</sup> As far as most pre-modern thinkers were concerned, to describe a man as a

mathematician was to describe him as a wizard; this was certainly true, for example, in the cases of John Napier and John Dee.<sup>76</sup>

By the time John Wilkins, one of the major contributors to the new philosophy in England, came to publish his *Mathematical magick* (1648), he felt it necessary to apologize for the title. By now, educated men were getting used to the idea that mathematics had an important place in natural philosophy (something which had always been denied by Aristotle), and mechanics was increasingly being seen as a science which depended upon natural phenomena, and so the workings of machinery could be seen as part of natural philosophy, and could shake off its old association with magic.<sup>77</sup> The process of incorporating mechanics into natural philosophy began with the Renaissance discovery of the *Mechanical questions*, attributed (wrongly) to Aristotle and first translated into Latin by Vittore Fausto in 1517. It required the recasting of mechanics from an art to one of the mixed mathematical sciences, before Descartes could insist, in 1644, that “there really are no reasonings in Mechanics which do not also pertain to Physics, of which it is a part or species.”<sup>78</sup> Undoubtedly one of the most important contributors to this transformation in attitudes to mechanics was Girolamo Cardano, a mathematician who was prominent in the occult tradition.

Cardano has still not attracted the scholarly attention he undoubtedly deserves and so his historical importance has yet to be properly assessed. It is clear, however, that his “complete account of the universe in a single volume”, *De subtilitate* (1550), is one of the earliest attempts to provide a comprehensive system of philosophy intended as a substitute for the Aristotelian system. One of the striking features of this work, most evident in its opening book on the principles of natural philosophy, is the way Cardano easily moves back and forth between explaining natural phenomena and the way machines work. Indeed, he uses his accounts of machinery to explain the

principles of natural motion, matter, the void, and so forth.<sup>79</sup> This approach, mixing the natural and the artificial, together with his emphasis in his mathematical works on the relevance of mathematics to the understanding of nature, is radically different from the traditional Aristotelian approach but contributed strongly to the “epistemological optimism with emphasis on the utility of knowledge” which the historian of mathematics, Jens Høyrup, has seen as characteristic of Renaissance occultism.<sup>80</sup>

Although historians of mathematics have tended to be even less interested in assessing the possible influence of occultism than historians of science have been, there seems to be a *prima facie* case for assuming that changing attitudes to mathematics, and changes in the intellectual status of mathematics, owed something to the reassessment of occult traditions which took place during the Renaissance. There is even a case to be made for the role of numerology in the Scientific Revolution, albeit a case that hinges almost entirely on Kepler and Newton. In the so-called ‘Classical scholia’, in which Newton sought support for universal gravitation in Pythagorean doctrine, he seemed to take seriously the belief that the number seven has some cosmic significance—as revealed by its appearance in music, optics, and the number of heavenly bodies in our system. These facts of nature, together with what Newton thought of as clear historical evidence of the significance of the number seven in ancient wisdom (that is to say, wisdom closer in time to that of Adam), revealed something about the mind of God.<sup>81</sup> Similarly, Kepler was at least as much concerned to know why God only created seven heavenly bodies in our system, as he was to understand what force actually moved the planets. Johannes Kepler believed that he had found a *natural* explanation for the fact that God only created six planets (instead of 10, 100, or even an infinite number) to circle the Sun in the details of what he

called the geometrical archetype.<sup>82</sup> It is important to note, however, that for both Kepler and Newton numerology had to be firmly grounded on empirical facts about the physical world. This set their numerology apart from those whose opinions about what a particular number might signify were based on mysterious traditions, or their own whims. This is precisely why Kepler objected so vigorously to the writings of Robert Fludd, and tried to ensure that his own work was not seen in the same light as Fludd's. Kepler found numerical significances in the Creation, while Fludd found them in his own imagination and imposed them on the natural world (at least, this is how Kepler saw the situation).<sup>83</sup>

It might be suggested that the latter kind of numerologist was the more common, and so Neoplatonising fantasists like Robert Fludd, for example, are more representative than Kepler or Newton. But this could easily be an illusion created by the prevailing historiography (or perhaps by the lack of an adequate historiography). Although Kepler's geometrical archetype is well known, it isn't always stressed in the literature that his deployment of the five Platonic solids in between the planetary spheres enabled him to answer the question as to why God only created six planets (the point being that, if God spaced the planets between these solids, He had to stop at six because He'd run out of solids, and the rules of geometry make it clear that not even God could create a sixth regular solid). Similarly, although Newton's analogy between the colours in the spectrum and the notes in the octave are plain for all to see in the *Opticks*, it is hardly ever mentioned, even in scholarly works dealing with Newton's optical theories. It is perfectly possible, therefore, that numerological concerns which are closer to Kepler's and Newton's than to Fludd's are waiting to be found in the writings of other contributors to the historical development of science.

The entirely undeniable role of alchemy in the development of modern science also needs to be understood in a carefully nuanced way. In an important article Lawrence Principe and William Newman have recently shown that our modern view of the nature of alchemy is severely distorted by various reconstructions of it which derive from nineteenth-century occultist movements, and have no real historical basis in the alchemy of the pre-modern period.<sup>84</sup> The historiographical rot set in when Enlightenment thinkers drew a spurious distinction between chemistry, in something like the modern sense, and alchemy, which was presented as being concerned solely with transmutation of base metal into gold.<sup>85</sup> This in itself can be seen as part of the trend, still active in the eighteenth century, to separate the new natural philosophy from magic. The need for this kind of separation of alchemy from chemistry became even more urgent for later spokesmen on science because of what Principe and Newman see as three “residues of Victorian occultism”.<sup>86</sup> Firstly, “spiritual alchemy”, which extended Jacob Boehme’s ecstatic use of alchemical imagery in his religion of self-purification and self-transmutation, implied that all alchemy was to be understood in this kind of mystical light. This view of alchemy was in turn transformed on the one hand into an exclusive concern with psychic transformation by the psychologist Carl Jung; and on the other into what they call a “panpsychic interpretation” of alchemy (in which alchemy was equated with an organic, vitalist, and generally enchanted worldview which was, so the story continued, inimical to modern science) by the doyen of comparative religious studies, Mircea Eliade. Newman and Principe are in the forefront of on-going efforts to recover the real history of alchemy from these obfuscations, and to show precisely how alchemy was absorbed into modern science, and what was left out (or, in this case, what came to be interpolated subsequently into the bogus history of alchemy). In connection with this, Principe and

Newman point out that not all alchemists subscribed to an animist, or even a vitalist, view of matter, and that such differences might have resulted in a different kind of take-up of alchemical ideas by reforming natural philosophers. Similarly, they point to recent work which has shown that alchemical matter theory was often corpuscularian, and even mechanistic, and which certainly played a part in the new matter theories of the Scientific Revolution.<sup>87</sup>

If alchemy was broken down into a general concern with chemical interactions and processes on the one hand and a concern with metallic transmutation on the other, and only the former made it into the new science, we can see a similar process with regard to the absorption of herbalism and the lore of Medieval bestiaries. Studies of flora and fauna in the pre-modern period were overlaid with assumptions about the religious, moral and symbolic significance of all God's creatures, as well as their potential for providing *materia medica*. Many of these assumptions, in what historians have referred to as the "emblematic worldview", derived from the belief in correspondences within the Great Chain of Being, and included various occult associations, based upon what were considered to be God-given signatures. As botany and zoology came to be included in the new science, however, much of this magical and mythological lore, once considered to provide essential information about the plant or animal in question, was excluded.

To understand this change in attitude about knowledge of natural things, we need to consider the effect of the discovery of the new world. Plants and animals from the new world came to the West devoid of any symbolic associations—they had no religious or moral significance deriving from either historical and religious legends, or from humbler folklore. Naturalists had no choice but to confine themselves to known facts about this new flora and fauna. In subsequent compendiums of natural history,

therefore, there was a clear shift towards treating all plants and animals in the same strictly descriptive way. Just as creatures unknown to European culture had to be recorded merely in terms of what could actually be observed, so the old folkloric associations were stripped away from familiar plants and animals. To a large extent this resulted in a less magical world picture, but it would be wrong to see this as a steady triumph of science over magic.<sup>88</sup>

Belief in the occult qualities of those plants and animals used in *materia medica*, supposedly based upon past experience anyway, was not affected by this increased emphasis upon observation. Furthermore, the tendency of explorers was to bring back just those plants which were deemed by native populations to be most useful in curing disease. More often than not, European doctors could not decide how, or even whether, such unknown drugs worked on the four humours of the body. Without so much as an *obiter dictum* from Aristotle, or Dioscorides, or some other ancient authority, it was often impossible to tell whether a plant worked through heat, cold or one of the other manifest qualities. Increasingly, therefore, medical thinkers declared new drugs to work by means of the alternative to the manifest qualities: occult qualities. This even led to a major re-working of medical and therapeutic theory, in which some diseases were held to be the result not of an imbalance in the humoral constitution, but a corruption of the whole substance of the body. The only drugs capable of curing these diseases were those that operated, likewise, on the 'total substance' of the body, not merely on a particular humor.<sup>89</sup>

So, while the occult qualities of *materia medica* were increasingly recognized and accepted into the new natural philosophy, there was a marked rejection of belief in the supposed symbolic significance of natural objects. This exclusion of symbolism as a factor relevant to the workings of the physical world is a general trend that can be



discerned elsewhere in Renaissance and early modern intellectual life. Again, it is easy to understand changing attitudes here in terms of a gradual fragmentation. The use of amulets or talismans was, of course, a prominent aspect of the magical tradition. In his investigation of the *Hidden Causes of Things* (*De abditis rerum causis*, 1548), Jean Fernel separated amulets which were supposed to work by the occult powers of natural objects from those supposed to work by magic spells—the power of words, pictures, or other symbols. The former seemed perfectly acceptable. Even much later Francis Bacon accepted the use of bloodstone, hung around the neck, to prevent nosebleeds. The colour of bloodstone was its signature, revealing that it must have an occult but natural power as a styptic.<sup>90</sup> Fernel and many others, however, had severe doubts that words or pictures could have any natural power. Although the Roman Catholic Church insisted upon the power of the priest to turn bread and wine into the Eucharist by intoning the words of the Mass, this was always regarded as a supernatural event. As Johann Wier insisted: “Words are brought forth from the mouth of the priest. But they are consecrated by the power and grace of God.” When God said “let there be light”, there was light not because it had been said, but because *God* had said it.<sup>91</sup>

According to the orthodox Christian view, if words or other symbols seemed to have any power it must have been due to the secret intervention of demons, accomplishing what on-lookers thought the symbols themselves had accomplished. As Thomas Aquinas pointed out, words have no power except over intellects. If a magician achieves power over inanimate nature by chanting words it must be because a demon has intervened, for its own purposes, and is making the magician believe he has succeeded.<sup>92</sup> Within the natural magic tradition, however, there was a belief that words *did* have their own natural power, and so could be used to accomplish natural

events or processes. This derived from the suggestion in Genesis 2, 19 that Adam named all things. It was assumed that Adam knew the true names of things, names which somehow captured the essence or true nature of the things and therefore had power over them. To us (and to Thomas) this simply looks like a non sequitur, but it seems clear that for many pre-modern thinkers there could be a power linking the “real”, God-given, name of a thing to its essence. In this essentially Neoplatonic view, language was not just used for communication, but was bound up with knowledge of things. If God had given names to things, they would not have been arbitrary signs, since God does nothing arbitrarily, and so knowledge of the names constitutes knowledge of Creation.

The revival of magic in the Renaissance led to increased hopes, therefore, that perhaps this Adamic language could be rediscovered, and Adam’s dominion over all things, lost at the Fall, could be restored. The major searchers after such ‘universal’ languages, therefore, were leading players in the reform of natural philosophy.<sup>93</sup> In his *Valerius Terminus* of 1603 Francis Bacon expressed his belief that man’s sovereignty and power over nature will only be restored “whensoever he shall be able to call the creatures by their true names”. By the time he came to write his *Great Instauration* (1620) he was still thinking of restoring “that commerce between the mind of man and the nature of things”, but it was clear that he saw this as an exercise in classificatory natural history rather than in linguistics. Similarly, the leading light of the Royal Society, John Wilkins denied the existence of an Adamic language with a natural magical power over things, but held out the hope that a language might be constructed which, by being rationally based upon the true nature of things, would prove to be a genuinely universal language capable of repairing “the ruins of Babel”.<sup>94</sup> The distinction is a subtle one. Words in the supposed Adamic language are held to have

power over things because they somehow capture the essence of the thing. Words in Wilkins's 'philosophical language' capture the essence of the thing by being based on (and somehow linguistically reflecting) a sound classificatory scheme which reveals the relationships between all things. What is clear is that Wilkins's language only has power over the intellects of its users, not over the objects being discussed. It is equally clear, however, that Wilkins's interest in a universal language first appeared in an early work which was undeniably magical in tone: *Mercury: Or the secret and swift messenger. Shewing how a man may with privacy and speed communicate his thoughts to a friend at any distance* (1641).

As in the case of mathematical magic, Wilkins can be seen to have contributed to the transformation of universal language schemes from an ambition of the magicians to one of natural philosophers. Another important aspect of this story can be seen in the Renaissance interest in the Jewish Kabbalah, a mystical system which invested words with real power. Christian cabbalism arguably originated with Giovanni Pico della Mirandola's *Conclusiones philosophicae, cabalasticae et theologicae* of 1486, but it soon became an important feature of Renaissance magic in its own right. In the end, it can be seen that cabbalism was not absorbed into the reformed natural philosophies, but this was not through lack of trying. It certainly figured in the universal language schemes, even in one of the latest, and potentially the greatest, of them, that of G. W. Leibniz. In the end, however, not even Leibniz could bring these universal language schemes to fruition and so they failed to find their way into the new science.<sup>95</sup> Nevertheless, historically these schemes can be seen as another aspect of the magical tradition which for a while were seriously discussed by leading shapers of the new philosophy, as they tried to incorporate what they recognized to be useful into their new philosophy.

A similar tale is to be told about the symbolic value of the supposed signatures. We have already noted how compendia of natural history began to jettison much of the earlier symbolic paraphernalia that were previously regarded as important pieces of information about God's creatures. As Brian Vickers has shown, the doctrine of signatures also began to attract sceptical scrutiny in the early modern period. Guy de la Brosse, for example, believed that the supposed resemblances were too uncertain, "like clouds, which can be made to look like anything that fantasy can project". John Ray, by contrast, could clearly see the signatures but refused to see any meaning in them. He noted that between some plants and various natural or artificial objects "so great a similarity exists that no one could fail to recognize it immediately nor could he persuade himself that it had ever come about by chance". Such resemblances were, on the one hand, "clear proof of intention on the part of nature" (Ray, like all his contemporaries, believed that nature, or God, does nothing in vain). On the other hand, as if to contradict this "clear proof", he suggested that the number of similarities was not "so great nor the signatures they bear so obvious and plain to everybody that they suggest a pointer or a deliberate plan on the part of Nature." The contradictions in Ray's account surely reflect a conflict between his belief in natural theology, with its assumption that the world is full of examples of God's design in the natural world, together with his religiously-inspired distaste of anything that would encourage the practice of magic.<sup>96</sup> The concept of signatures was not simply discarded, it was broken up, and partially incorporated into the new natural philosophy, appearing especially in the tradition of natural theology, which sought to prove God's wisdom and beneficence by pointing to seemingly obvious cases of intelligent design in nature.

Although astrology is now very far beyond the pale as far as most scientists are concerned (a few extreme empiricist statisticians notwithstanding), there was a time when it was a mainstream subject in the universities, particularly in Medical Faculties. What's more, during the re-drawing of the boundaries around and between natural philosophy and magic, there was a time when astrology looked as though it might continue to be included even in the new science. Astrology had always attracted detractors but the evidence in its favour seemed to override all arguments.<sup>97</sup> The effect of the moon on the tides seemed undeniable and the Sun's movement through the Zodiac defined the seasons. It was also hard to believe that God had placed the myriad fixed stars, as well as the Sun, Moon and planets, without having a very good reason for doing so. Kepler was in many ways an idiosyncratic thinker but he spoke for many devout believers when he insisted that we had to consider God's reasons:

For if we do not, we shall be driven to admit that God acted arbitrarily in the universe, even though perfectly good rational procedures were open to Him.

And this is a conclusion I will not accept on anyone's authority...<sup>98</sup>

Even so, Kepler recognised the problems with traditional astrology and jettisoned much of its old lore when he came to write his treatise *On the more certain foundations of astrology* (*De fundamentis astrologiae certioribus*, 1602).<sup>99</sup>

Certainty seems to have been an important issue in the fragmentation of astrology. The rise in intellectual status of mathematics, which was such an important aspect of the mathematization of the world picture, depended to a large extent upon arguments about the greater certainty of mathematics. So-called judicial astrology was an early casualty. Notoriously unreliable, and attracting many cogent arguments against its validity, the personal divinatory aspects of astrology were already being rejected by the early seventeenth century.<sup>100</sup> Once again, however, we can see that the

story was one of fragmentation, and partial absorption, not wholesale rejection. Kepler's own attempt to establish more certain principles of astrology came to nothing, but even at the end of the seventeenth century we can see continuing attempts to establish, on empirical grounds, the links between the heavenly movements and the weather.<sup>101</sup>

For a while it even looked as though Newtonian science, the apogee of certainty in mathematical physics, would embrace one major aspect of astrology. As Maupertuis wrote, even as late as 1742, "one of the greatest astronomers of the century [Newton] has spoken of comets in a manner which re-establishes them in all the reputation of terror where once they were".<sup>102</sup> Newton and some of his close followers, including the down-to-earth Edmund Halley as well as the more religiously fanciful William Whiston, saw comets as God's way of continuing to adjust and reshape the nature of our planetary system. The gravitational pull of a passing comet was considered as the likely cause of the Noachian Deluge, since the Almighty prefers to make use of "Natural Means to bring about his Will". Bearing in mind that God does nothing in vain, it seemed likely that comets might well be once again, "the Instruments of Divine Vengeance".<sup>103</sup>

It would be absurd to suppose that Newton and his followers were determined to rescue, by hook or by crook, some aspect of astrology. Clearly, they were not. Newton's principle concern was to allow continued discourse about God within natural philosophy. For Newton the Cartesian system, which required God only at the Creation, after which His intervention in the mechanistic system of the world was never required, "was made on purpose to be the foundations of infidelity".<sup>104</sup> Newton's belief that God had to continually tinker with his system to keep it running smoothly outraged his continental rival, G. W. Leibniz, who was appalled that

Newton could imagine God to be such a poor artificer. As far as Newton was concerned, however, the use of comets as the natural means by which God winds up and replenishes the system allowed him to avoid atheistic interpretations of his philosophy, without actually having to suppose direct supernatural interventions by God.<sup>105</sup> Here then we can see the old astrological belief in comets as portents of great change, and instruments of God's wrath, being absorbed for a while into the new natural philosophy. By the late eighteenth century, however, thanks to increasing secularisation no less than to the increased success of Newtonian mechanics in explaining our solar system without recourse to in-puts from comets, even this aspect of astrology was excluded from science.<sup>106</sup>

Another significant example of the adoption, and adaption, of magical thinking concerns the transformation of the magnet from one of the most occult of occult objects to a body with a unique but easily demonstrated power, which could even be invoked to explain various non-occult phenomena. A well-known magical manuscript on the magnet, written by Pierre de Maricourt in 1269, was first printed in 1558, when the value of magical works was becoming widely recognised. It must have been after reading this that William Gilbert, so-called father of magnetic science, hit upon the idea of using magnetism to explain the Copernican rotations of the Earth. Magnets are capable of spontaneous movement, Gilbert reasoned, and therefore must be endowed with souls, because (according to Aristotle) only creatures with souls are capable of self-movement. Using experiments and ideas highly reminiscent of those found in Maricourt's *Epistle on the Magnet*, Gilbert then went on to show that the Earth was a giant magnet, and must have a soul, and be capable of making itself move in the ways required by Copernican astronomy.<sup>107</sup> Subsequent writers, particularly in England, recognised the value of Gilbert's attempt to provide a physical explanation

of the Earth's movement (something which Copernicus never provided), but evidently found his emphasis upon a magnetic soul too animistic for their tastes, and focussed instead on Gilbert's talk of a magnetic *orbis virtutis*, surrounding a planet. Where Gilbert had used the magnetic soul to suggest planets moved themselves, later natural philosophers, starting with Kepler, developed a dynamic account of planetary movements based on tangential motions past the sun and an attractive force towards it. Talk of magnetic souls was replaced by talk of 'magnetic attractions', 'magnetic virtues', and eventually 'attractive principles' and 'gravitating powers'; such talk was less animistic, but it was not less occult, even though for us it seems definitely more 'scientific'.<sup>108</sup> The culmination of this trend was the natural philosophical essay by Sir William Petty, *A new hypothesis of springing or elastique motions* (1674), in which he actually sought to explain phenomena like elasticity, solidity and fluidity, expansion and contraction, and more, by assuming that, just as all planets were spherical magnets in Gilbert's cosmological scheme, so all atoms are spherical magnets. Although magnetic attractions and repulsions continue to be occult qualities, magnetic phenomena can be clearly and easily demonstrated on a laboratory workbench, and so magnets can be used to provide legitimate explanations in natural philosophy.<sup>109</sup>

There were even some thinkers, although mostly on the fringes of natural philosophy, who tried to absorb demonology into the new natural philosophy. Henry More, the Cambridge Platonist divine who introduced the teaching of Cartesianism into Cambridge, Joseph Glanvill, FRS and apologist for the new philosophy; and even for a while Robert Boyle, were keen to make the study of demons, witchcraft, and ghosts an important part of the new experimental philosophy. The motivation was perfectly clear: to combat the up-take of Cartesian and other versions of the



mechanical philosophy by irreligious thinkers who were seeking to promote an entirely materialist worldview. The would-be experimentalist demonologists wanted to demonstrate that there were phenomena which could not be explained in terms of the mechanical philosophy, and so immaterial beings and immaterial principles had to be acknowledged.<sup>110</sup>

I believe it would be possible to continue in this vein, showing how different aspects of the magical tradition were partially taken up by natural philosophers, while other aspects were entirely excluded. In all cases, as with the examples briefly discussed here, the story will be one where the historical complexities derive from a host of contingencies. It is fairly obvious, for example, that the precise way in which alchemy, or part of it, became absorbed into natural philosophy was different from the way that so-called ‘mathematical magic’—the use of machinery to improve human faculties—was adopted.<sup>111</sup> Furthermore, some prominent aspects of the natural magic tradition, such as a belief in the natural power of words, were not included within the new boundaries at all. In other cases, aspects of the tradition were only taken up in a very restricted sense, as in the case of numerology, which seems to have led Kepler and Newton to draw specific conclusions about the natural world, but can hardly be said to have been a general influence.<sup>112</sup> If we bear in mind, also, that the magical tradition was undoubtedly a major source for the experimentalism of the new philosophies, and for the idea that knowledge of the natural world should be useful for the benefit of mankind, it seems hard to deny the claim that the new philosophies were greatly indebted to the magical tradition.<sup>113</sup>

*Why the Change?*

The question arises, therefore, as to why this sea-change occurred. Why was the map of knowledge redrawn between the end of the Renaissance and the beginning of the Enlightenment? Why were the boundaries redefined so that natural magic lost its identity by becoming largely absorbed into the new ‘natural philosophy’ (which now, thanks to the experimental method, the integral use of mathematics, and the concern with pragmatism was closer to our modern concept of science than it was to the earlier tradition of contemplative natural philosophy), while symbolic magic came to be seen, by the educated at least, as superstitious nonsense,<sup>114</sup> and demonology, formerly a borderline category linking religion and natural philosophy, became first of all an entirely religious category, and with increasing secularization was thoroughly rejected?<sup>115</sup>

As with so many other problems in history, the answers to this question are no doubt legion. We have already considered a few reasons along the way, such as the change in status of mathematics, helped by the discovery of the supposedly Aristotelian *Quaestiones mechanicae*, but it is beyond the scope of this article to survey all the other possible factors. It is clear, for example, that the full story could not be told without paying careful attention to the social and political context of Renaissance and Reformation Europe, and how developments in these spheres affected intellectual life.<sup>116</sup> What I want to do here is simply to consider briefly some of the more immediate reasons why the boundaries of magic and natural philosophy were redrawn in just the way they were. By ‘immediate’ I mean those reasons which arose directly out of the efforts of Renaissance and early modern thinkers to improve their understanding of the natural world.

Perhaps the first thing to mention in this connection was the change in the intellectual status of magic as a result of the discovery of the essentially religious

writings attributed to Hermes Trismegistus. Thanks to a generally accepted belief in the wisdom of Adam, it was usually assumed in the pre-modern period that knowledge was something that needed to be recovered from the past. Adam knew all things, but thanks to the Fall, this wisdom had been successively forgotten. For the pre-moderns, therefore, thinkers of great antiquity were more likely to know more—to have forgotten less of the Adamic wisdom—than a contemporary thinker. This belief is most familiar to historians of science through the common designation of the Copernican theory as the Pythagorean theory.<sup>117</sup> The Copernicans knew that if they were to have any chance of persuading their contemporaries of the truth of the Copernican theory they had to show that it had been believed in the past. The ancient sage, Hermes Trismegistus, was regarded as a contemporary of Moses, and he was seen to be responsible for transmitting the Adamic wisdom to the pagan Greeks, as Moses had transmitted it to the Jews. This belief was easy to sustain in the light of the fact that the newly discovered Hermetic writings showed clear foreshadowings of Christian belief, including its trinitarianism. As we now know, these supposed foreshadowings were in fact echoes of Christian belief, since these writings were actually compiled by Neoplatonists in the early centuries of the Christian era.

The first translator of the Hermetic Corpus (a substantial part of it, at least) was Marsilio Ficino who was clearly fascinated by Neoplatonic theurgical beliefs and who began to develop his own theory of what D. P. Walker called ‘spiritual magic’ in his *De vita coelitus comparanda* (1489). Ficino’s work proved immensely influential and helped to promote the view that Hermes Trismegistus was above all else a magician.<sup>118</sup> This identification of Hermes as a magus was helped by the fact that, as well as the Neoplatonic theistic writings attributed to him, there were also a considerable number of astrological, alchemical and natural magical texts also

attributed to this great sage. Given the belief in Adamic wisdom, and the belief in the great antiquity of the Hermetic writings, magic came to be seen as one of the oldest forms of knowledge, and was therefore newly invested with great respectability. After centuries of being disparaged by the Church, magic came to be seen as a major aspect of Adamic wisdom. Accordingly, as Eugenio Garin has suggested, there was a brief time, shortly after the discovery of the Hermetic Corpus, when it was acceptable to be called a magus, and to acknowledge oneself to be a magus (remember, we have already seen that it was much more usual to deny that one was a magician).<sup>119</sup> It is hardly surprising therefore that reforming natural philosophers of the Renaissance and early modern periods should look with fresh eyes at the magical tradition, and consider more seriously than before what it had to offer.<sup>120</sup>

Another reason why the boundaries of magic came to be redrawn arose from rapid developments in the understanding of earlier magical traditions as a result of the humanist scholarship of the Renaissance. In particular, the recovery of the works of Ancient Neoplatonists, such as Plotinus, Proclus, Iamblichus and others, revealed a theory of magic in which “spiritual and demonic magic” played a greater role than natural magic. This alternative to the Aristotelian tradition first became known as a result of the work of the famous Florentine philosopher and translator, Marsilio Ficino, whose *De vita coelitus comparanda* of 1489 was a full exposition of the theory of magic which drew not only upon Aristotelian traditions of occult qualities but also upon the more theurgical theorising of the later Neoplatonists. Although Ficino himself seems to have managed to stay within the confines of natural magic as it was traditionally conceived (with the emphasis on the *natural*), his exposition drew attention to the fact that later Neoplatonists seemed to believe that occult qualities in matter were clear signs of divine or demonic presence within the matter. For the

pagan Neoplatonists, in other words, the occult but *natural* effects discussed in traditional natural magic were, in fact, *supernatural* effects brought about directly by gods or demons. Although such ideas were pagan and could easily be shown not to fit in with Christian Aristotelianism, they ensured that the boundary demarcation between natural and supernatural and the abilities of demons were placed firmly on the agenda of scholarly discussions. In this way, occult qualities, formerly hardly discussed within the scholastic tradition, became important items for discussion.<sup>121</sup>

One of the most important of such discussions was that of the notorious secular Aristotelian philosopher, Pietro Pomponazzi. Pomponazzi was, as Brian Copenhaver has recently said, “entirely and aggressively naturalist” and in 1520 he wrote a treatise *On the causes of marvelous natural effects and on spells*, in which he explicitly intended to make demons redundant for any understanding of the natural world. One of his arguments was that, even if demons were capable of knowing better than men all the occult qualities of things and how to accomplish things by bringing together sympathetic actives and passives, because demons were spiritual, incorporeal, beings they were completely incapable of manipulating matter to accomplish anything by their knowledge.<sup>122</sup> Once again, Pomponazzi's book, like Ficino's, stimulated debate about occult qualities, demons, and the demarcations between and around them. By rejecting the possibility of demonic intervention, Pomponazzi greatly expanded the role of the supposed occult qualities of matter. Such qualities could stimulate thinking about the nature of matter itself, and could subsequently be absorbed into the new natural philosophy. Meanwhile, sceptical philosophers had a new set of arguments for dismissing demons as ineffectual, and ultimately as nothing more than the result of superstitious beliefs.<sup>123</sup>

Another important stimulus towards a new and detailed consideration of occult qualities arose out of university medical faculties. We have already noted that developments in botany and other subjects affiliated to the production of *materia medica* resulted in increased numbers of new drugs being designated as “occult” in their operation, because their efficacy did not depend upon their effects upon the manifest qualities of the patients’ humours. This coincided with awareness of the need for reform of medical theory from another quarter. The increased prevalence of pestilential diseases in a Europe where bubonic plague was endemic and where syphilis was cutting a swathe through all classes of society presented problems for traditional medical theory. Galen saw all disease in terms of a disturbance of the four humours such that the normal healthy temperament (the balance of the humours in the body) was disrupted. It follows from this that diseases do not have a separate existence in their own right. The difficulty with this individualistic physiological approach to sickness, seeing every illness as the special problem of one patient, is that it cannot easily explain conditions which seem to be infectious. Why should one patient’s physiological disruption be capable in some cases of being passed on to others with different constitutions or temperaments? The difficulty is especially severe for Galenic theory in the case of epidemic diseases, such as plague. Epidemic pestilences strongly suggest, contrary to ancient authority, that diseases have a kind of life of their own; they are real, distinct entities, which can pass from one person to another, or can simultaneously attack great numbers of people irrespective of their individual temperaments. A new understanding of the nature of diseases demands new ways of dealing with them, and the sixteenth century saw three major attempts to reform medical theory. The three would-be reformers, Paracelsus, Girolamo Fracastoro and Jean Fernel all drew upon occult traditions in their suggested reforms.

Paracelsus looked to alchemy, not just as a way of producing new medicines, but as a way of understanding the nature of the physiology, and the nature of disease.

Fracastoro developed the idea of “seeds” of disease, seminal principles capable of growing in the body and disrupting it, while Fernel believed that pestilences acted not on the humours, but on the substantial form of the body, which Fernel called the “total substance” of the body, and they did so, not by affecting the manifest qualities but by means of some occult power over the total substance.<sup>124</sup>

The works of Ficino, Pomponazzi, Paracelsus, Fracastoro, and Fernel are, of course, just salient points in a rapidly changing landscape of intellectual discussion. Throughout the sixteenth century the nature and the role of occult qualities become increasingly prominent in natural philosophizing. This was bound to have unfortunate repercussions for traditional Aristotelianism, since, although occult qualities were allowed for in scholasticism, and traditional natural magic throughout the Middle Ages was loosely premised upon Aristotelian assumptions (alchemy, for example, although going far beyond anything to be found in Aristotle's writings still assumed the truth of the four elements and four qualities), in fact there was very little in Aristotle himself about occult qualities.<sup>125</sup> Indeed, it became increasingly obvious during the Renaissance, when Aristotle came to be studied in the original Greek, that the natural magic tradition owed a great deal to medieval and Arabic interpolations, for example, from Thomas Aquinas, Albertus Magnus, Avicenna, and Alkindi.<sup>126</sup> More to the point, the ideal of science in the Aristotelian tradition was based on the form of the logical syllogism (deductive reasoning), but the premises, the starting points upon which the reasoning was based, had to be uncontroversial, evident truths to which all could freely assent. Small wonder, therefore, that the main emphasis in natural philosophical argument was on the supposedly *manifest* qualities, which could

fulfill the criteria of being undeniable and evident to all.<sup>127</sup> It was one thing, within this system to occasionally have to resort to occult qualities in one's explanations; it was quite another, however, to see occult qualities playing an increasingly prominent role in a widespread range of natural phenomena. There was a real crisis in Aristotelianism, therefore, concerning the very possibility of dealing with *insensible* properties and entities in a philosophy that was supposedly grounded on human sensation. When writers like Pomponazzi, Jean Fernel, and Daniel Sennert can be seen to be elevating the role of occult qualities in Aristotelianism it seems legitimate to ask whether they are best seen as eclectic Aristotelians or as contributors to the demise of Aristotelianism. Whatever the truth of that, we cannot help but conclude, I think, that Renaissance developments in the notion of occult qualities resulted in a major re-arrangement, in which these qualities came to play a much greater role in reformed versions of natural philosophy, and eventually became absorbed into the mainstream of the new philosophies which completely displaced Aristotelianism.<sup>128</sup>

Further difficulty for Aristotelian natural philosophy was caused by emerging problems with the theory of substantial forms. These arose especially as a result of considering the nature of what we would call chemical compounds, compared with mere mixtures, and why new substantial forms seem to be created in the one case, but not in the other. Just as the medical reformers turned to the occult to develop new theories of medicine, so innovative scholastics and anti-Aristotelians alike turned to alchemy to help understand the production of new substances. At the leading edge of this work, as performed by alchemists like Daniel Sennert and Robert Boyle, the notion that the substantial form defined a body became untenable when it was realized that the original constituents of a mixt (what we would call a chemical compound) could be recovered. According to scholastic theory this required the recreation of the



constituents' substantial forms after they had been replaced by the new substantial form of the mixt. Alternative explanations in terms of the conjunction of unchanging atoms or corpuscles began to replace Aristotelian accounts but these explanations, as William R. Newman has shown, owed more to alchemical theorizing than they did to the emerging mechanical philosophy.<sup>129</sup>

Finally, unlikely as it may seem to us (or to those of us who remain, like David Brewster, recalcitrant in their belief that all magic was merely the production of knaves and fools), there is every reason to suppose that, as far as Renaissance thinkers were concerned, the occult sciences were the most likely source for the reform of natural philosophy, and for the establishment of a true understanding of God's Creation. Indeed, to a large extent they were the *only* alternative sources of natural knowledge.

It has been suggested by Brian Vickers that modern science emerged as the scientific mentality overcame the occult mentality that had been dominant among earlier thinkers. The assumption here is that Paracelsus, say, representing the occult mentality, chose the wrong path to reform natural knowledge, while Descartes, representing the scientific mentality, chose the right path.<sup>130</sup> In a sense, of course, this is true—Cartesianism has proved more influential on subsequent scientific thinking than Paracelsianism, but we cannot infer from this that Descartes was more scientific in his thinking than Paracelsus, unless we choose to make it a matter of our definitions of who is a scientific thinker and who is not. Relying on our perfect hindsight we can easily declare Descartes to be a more scientific thinker than Paracelsus, but at the time of Descartes's death in 1650 judgments as to the relative merits of these two thinkers could not have been couched in these terms.

Furthermore, for the sake of the argument being presented here, Paracelsus is by no means the best representative of magical thinking to choose. His thinking seems to be at best confused and at worst willfully obscure, and was clearly recognized as such by many contemporaries. But not every thinker in the occult tradition was as poor a communicator (or as weak a thinker, if that was his problem) as Paracelsus. Many, on the contrary, must be counted among the greatest thinkers of their age, and they believed, like Descartes, that they had discovered the key to understanding, and explaining natural phenomena. Although Jean Fernel chose very deliberately to argue for the increased importance of occult qualities in natural philosophy and in the theory and practice of medicine, he did so in accordance with the best canons of logic and rhetoric of the day, and by marshalling powerful evidence and argument in support of his views. To dismiss Fernel as a man with an “occult mentality”, with implications of woolly-minded inconsequentiality if not downright irrationality, would be entirely unjust. The same is true, for the most part, of other thinkers in the magical tradition. Girolamo Cardano, and Cornelius Agrippa, to mention but two, should be recognized as leading shapers of European thought, not simply dismissed as deluded contributors to a worthless pseudo-intellectual tradition.

This is not to say that all magicians should *ipso facto* be honoured as great thinkers. We need to exercise the same care in making judgments about the historical significance of these thinkers as we would in the case of those who are supposed contributors to the history of science. Lauren Kassell has recently shown that the London-based astrologer Simon Forman, was an autodidact who was barely capable of understanding the tradition he wished to exploit for his own personal gain. If we wish to understand how practitioners in the occult tradition, even more than medical practitioners, came to be seen as frauds and charlatans, we could start with Forman.

Similarly, the historical significance of Robert Fludd has not yet been established beyond doubt, in spite of sympathetic treatments of his work by a number of scholars.<sup>131</sup>

The leading thinkers in the magical tradition, at any rate, should be seen as thinkers who were trying to find solutions to problems which the Aristotelian and Galenic traditions could not resolve, and who turned to the occult, not because they were befuddled fools with an occult mentality, but quite simply because occult traditions seemed to offer the most likely source of help. When the Aristotelian theory of substantial forms, and the associated hylomorphic matter theory began increasingly to seem inadequate, natural philosophers turned to alchemy as a likely pointer to alternative ways of understanding the relationship between bodies and their properties.<sup>132</sup> When Galenic medical theory, which relied almost exclusively on the balance (or imbalance) of the four qualities in the body for understanding disease and treating it, came to be seen as increasingly inadequate, medical reformers like Fernel, Fracastoro, and the Paracelsians, all turned in one way or another to occult qualities as an alternative.<sup>133</sup> Similarly, every one of the Renaissance thinkers who tried to develop new systems of philosophy, intended to completely replace Aristotelianism, relied to a large extent on aspects of the magical tradition. So much so, in fact, that each of these system-builders, can be seen as contributors themselves to the magical tradition. The title of Girolamo Fracastoro's *De sympathia et antipathia rerum* (1550) reveals its magical nature, but Girolamo Cardano's more cryptically titled *De subtilitate* (1554), which includes a substantial book "On Marvels, and the way to represent diverse things beyond belief", is equally indebted to the occult tradition.<sup>134</sup> Bernardino Telesio's *De rerum natura iuxta propria principia* (1587) assumes that all things are sentient and relies heavily on ideas of spirit which derive from the earlier

magical philosophy of Ficino. Furthermore, Telesio was a major influence on at least two other thinkers who were indebted to the magical tradition, Tommaso Campanella, author of *De sensu rerum et magia* (1620) and other magical works, and Francis Bacon, whose own system of philosophy, combined Telesian ideas on spirit with alchemical ideas to make what has been described as a semi-Paracelsian cosmology.<sup>135</sup> The inventive group of Italian system-building “nature philosophers”, as they are usually known, also included Francesco Patrizi, Giordano Bruno. The magical nature of Bruno’s world-view is so well known that it can be taken for granted, but Patrizi’s views are indicated, if not by the title of his great system, *Nova de universis philosophia* (1593) then by the fact that he published it alongside his own translation of Chaldean and Hermetic works, under the title *Magia philosophia* (1593).<sup>136</sup>

This situation, in which would-be reformers of natural philosophy turned to the occult tradition as the most likely way out of all difficulties, continued even late into the seventeenth century, to the period seen as witnessing the dramatic decline of magic. Robert Boyle, recognizing the inadequacy of strict versions of the mechanical philosophy, including Cartesian claims that there were no new motions generated in nature, only transfers of motion from one part of the system to another via collisions, turned once again, as the opponents of Aristotelianism had before him, to alchemy. Newton, recognizing the absurdity of Cartesian vortex theory as an explanation for planetary movements and for gravity, preferred to rely instead upon the assumption that bodies could attract one another across empty space.

The example set by Newton makes it hard to deny that, if reformers of natural philosophy believed the occult sciences offered the most likely source for a viable alternative to Aristotelianism, they were right. Descartes was proud of the fact that he

had eschewed all occult qualities from his system, and so in a sense believed he had succeeded where Aristotelianism had failed (since it had never quite managed to dispose of occult qualities). But for many, the Cartesian system could be seen to be ultimately unworkable, and rather than eschewing occult qualities, they embraced them as the only realistic alternative.<sup>137</sup> In so doing, occult qualities became absorbed into mainstream reformed natural philosophy. The triumph of Newtonianism, then, with its basic premise that all phenomena could be explained in terms of attractive and repulsive particles capable of acting at a distance, showed not only that Newton was right, but that earlier would-be reformers of natural philosophy who had tried to draw upon the magical tradition were not too far wrong.

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<sup>1</sup> *The diary of Benjamin Robert Haydon*, 5 vols, ed. W. B. Pope (Cambridge, MA, 1960-63), ii, p. 173.

<sup>2</sup> William Blake, *Jerusalem: The emanation of the giant Albion* (1804), Plate 15, lines 15-20; see Donald D. Ault, *Visionary physics: Blake's response to Newton* (Chicago, 1974).

<sup>3</sup> John Keats, *Lamia* (1820), Part II, lines 229-37. On Keats's location in Enlightenment science see, Donald C. Goellnicht, *The poet-physician: Keats and medical science* (Pittsburgh, 1984).

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<sup>4</sup> William Blake, *The [first] book of Urizen* (1794).

<sup>5</sup> See, for example, Gerd Buchdahl, *The image of Newton and Locke in the age of reason* (London, 1961); P. M. Rattansi, "Voltaire and the Enlightenment image of Newton", in H. Lloyd-Jones, V. Pearl and B. Worden (eds), *History and imagination: Essays in honour of H. R. Trevor-Roper* (London, 1981), pp. 218-31; I. B. Cohen, "The eighteenth-century origins of the concept of scientific revolution", *Journal of the history of ideas*, xxxvii (1976), 257-88.

<sup>6</sup> Alan E. Shapiro, in his "Artists' colours and Newton's colours", *Isis*, lxxxv (1994), 600-30, suggests that Newton discovered that white light was made of an infinite number of spectral colours (p. 600). This is just loose talk, however, written in the light of our knowledge of the electromagnetic spectrum. Newton himself clearly believed that there were only seven primary colours.

<sup>7</sup> Isaac Newton, *Opticks, based on the fourth edition London, 1730* (New York, 1952), Bk I, Pt II, Prop. III, Problem I, 126. My emphasis. The ellipses indicate where I have omitted Newton's labelling of the lines in accordance with his accompanying diagram.

<sup>8</sup> Isaac Newton, "An hypothesis explaining the properties of light, discoursed of in my several papers", in I. B. Cohen (ed.), *Isaac Newton's papers and letters on natural philosophy* (Cambridge, MA, 1978), 192-3.

<sup>9</sup> Newton had shown, by further prismatic experiments, that the colours of the spectrum could not themselves be broken into further colours. Repeated refractions merely separated the colours further apart, but did not alter their colours. *Opticks*, Book I, Part I, Prop. V, Theorem IV, *ed. cit.* (ref. 7), 73-5.

<sup>10</sup> See, for example, A. I. Sabra, *Theories of light from Descartes to Newton* (Cambridge, 1981).

<sup>11</sup> *The optical papers of Isaac Newton*, volume I, edited by Alan E. Shapiro (Cambridge, 1984), 543. Newton defended this musical analogy in a letter to an Oxford undergraduate, John Harrington, in May 1698, where he wrote: "I am inclined to believe some general laws of the Creator prevailed with respect to the agreeable or displeasing affections of all our senses". I. Newton, *Correspondence*, edited by H. W. Turnbull, *et al.*, 7 vols (Cambridge, 1959-77), iv, 275, quoted by Shapiro, *ed. cit.*, 547.

<sup>12</sup> The classic account is still J. E. McGuire and P. M. Rattansi, "Newton and the 'Pipes of Pan'", *Notes and records of the Royal Society of London*, xxi (1966), 108-43, pp. 115-7. For the Latin text see Paolo Casini, "Newton: The classical scholia", *History of science*, xxii (1984), 1-58. A complete edition, including translations, of these proposed scholia is now available: Volkmar Schuller, "Newton's Scholia from David Gregory's estate on the Propositions IV through IX Book III of his *Principia*", in

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W. Lefevre (ed.), *Between Leibniz, Newton and Kant* (Dordrecht, 2001), 213-65. For Newton's work on music see Penelope Gouk, "The harmonic roots of Newtonian science", in J. Fauvel, R. Flood, M. Shortland and R. Wilson (eds), *Let Newton be!* (Oxford, 1988), 101-25; and idem, *Music, science and natural magic in seventeenth-century England* (New Haven, 1999), 224-57.

<sup>13</sup> See R. S. Westfall, *Never at rest: A biography of Isaac Newton* (Cambridge, 1980), 351-59; and idem, "Isaac Newton's *Theologiae gentilis origins philosophicae*", in W. Warren Wagar (ed.), *The Secular Mind: Transformations of faith in modern Europe* (New York, 1982), 15-34. See also, Matt Goldish, "Newton's *Of the Church*: Its contents and implications", in J. E. Force and R. H. Popkin (eds), *Newton and religion: Context, nature and influence* (Dordrecht, 1999), 145-64.

<sup>14</sup> John Maynard Keynes, "Newton, the man", in The Royal Society, *Newton tercentenary celebrations* (Cambridge, 1947), 27-34. Keyes was one of the first scholars to accept that Newton's undeniable interest in alchemy was sincere and highly positive. For other treatments of Newton's occult interests see, for example, McGuire and Rattansi, "Newton and the 'Pipes of Pan'" (ref. 12); R. S. Westfall, "Newton and alchemy", in Brian Vickers (ed.), *Occult and scientific mentalities in the Renaissance* (Cambridge, 1984), 315-35; B. J. T. Dobbs, *The foundations of Newton's alchemy: Or, "The hunting of the Greene Lyon"* (Cambridge, 1975); idem, *The Janus faces of genius: The role of alchemy in Newton's thought* (Cambridge, 1991); Carolyn Merchant, *The death of nature: Women, ecology and the Scientific Revolution* (San Francisco, 1980); John Henry, "Newton, matter and magic", in J. Fauvel, et al. (eds), *Let Newton be!* (ref. 12), 127-45.

<sup>15</sup> Paolo Rossi, *Francis Bacon: From magic to science* (London, 1968); Charles Webster, *From Paracelsus to Newton: Magic and the making of modern science* (Cambridge, 1982); Brian Copenhaver, "Astrology and magic", in C. B. Schmitt and Q. Skinner (eds), *The Cambridge history of Renaissance philosophy* (Cambridge, 1988), 264-300; idem, "Natural magic, hermetism, and occultism in early modern science", in D. C. Lindberg and R. S. Westman (eds), *Reappraisals of the Scientific Revolution* (Cambridge, 1990), 261-302; Ron Millen, "The manifestation of occult qualities in the Scientific Revolution", in M. J. Osler and P. L. Farber (eds), *Religion, science and worldview: Essays in honor of Richard S. Westfall* (Cambridge, 1985), 185-216; John Henry, "Occult qualities and the experimental philosophy: Active principles in pre-Newtonian matter theory", *History of science*, xxiv (1986), 335-81; Paul Richard Blum, "Qualitates occultae: Zur philosophischen Vorgeschichte eines

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Schlüsselbegriffs zwischen Okkultismus und Wissenschaft”, in August Buck (ed.), *Die okkulten Wissenschaften in der Renaissance* (Wiesbaden, 1992), 45-64.

<sup>16</sup> Bruce Moran, *Distilling knowledge: Alchemy, chemistry, and the Scientific Revolution* (Cambridge, MA, 2005), 1-7 and 185-9; William R. Newman, *Atoms and alchemy: Chymistry and the experimental origins of the Scientific Revolution* (Chicago, 2006), 1-20 and 224-5.

<sup>17</sup> Examples of this approach can be seen in a number of papers in M. L. Rhigini Bonelli and W. R. Shea (eds), *Reason, experiment, and mysticism in the Scientific Revolution* (London, 1975), particularly: Paolo Casini, “Newton, a sceptical alchemist?”, 233-8; A. Rupert Hall, “Magic, metaphysics and mysticism in the Scientific Revolution”, 275-82; and perhaps even Paolo Rossi, “Hermeticism, rationality and the Scientific Revolution”, 247-73. But see also, Bronislaw Malinowski, *Magic, science and religion and other essays* (Boston, 1948); and Mary B. Hesse, “Reason and evaluation in the history of science”, in M. Teich and R. M. Young (eds), *Changing perspectives in the history of science* (London, 1973), 129-47. For further discussion see David Katz, *The occult tradition from the Renaissance to the present day* (London, 2005), 11-16.

<sup>18</sup> It is important to exonerate Brian Vickers from these charges. Professor Vickers’s extensive, careful and thoughtful scholarship has done much to increase our understanding of the history of magic. Even so, I have to say that I find his distinction between two “mentalities”, occult and scientific, in the pre-modern period, is a clear case of putting the positivist cart before the historical horse. See his Introduction to Vickers (ed.), *Occult and scientific mentalities in the Renaissance* (ref. 14), 1-55.

<sup>19</sup> Sir David Brewster, *Memoirs of the life, writings and discoveries of Sir Isaac Newton*, 2 vols (Edinburgh, 1855), ii, pp. 374-5.

<sup>20</sup> The denials are based on a misreading of a single comment by Newton in a letter to Richard Bentley written in February 1693. Although this comment, on a superficial glance, might look like a denial of action at a distance, it is not. The misreading was pointed out long ago by Emile Meyerson, “Leibniz, Newton, and action at a distance”, in idem, *Identity and reality* (London, 1930), 447-56; and reiterated more recently in John Henry, “‘Pray do not ascribe that notion to me’: God and Newton’s gravity”, in James E. Force and Richard H. Popkin (eds), *The books of nature and Scripture: Recent essays on natural philosophy, theology and Biblical criticism in the Netherlands of Spinoza’s time and the British Isles of Newton’s time* (Dordrecht, 1994), 123-47. For the quotation in question, see Cohen (ed.), *Isaac Newton’s papers and letters on natural philosophy* (ref. 8), 302.



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<sup>21</sup> Newton, *Opticks* (ref. 7), Queries, 1, 4, 21, 29, and 31, pp. 339, 352, 371, 375-6. The role of Newton's alchemy in his concept of force was first suggested by R. S. Westfall, "Newton and the Hermetic tradition", in Allen G. Debus (ed.), *Science, medicine and society in the Renaissance*, 2 vols (New York, 1972), ii, 183-98; see also idem, "Newton and alchemy", in Vickers (ed.), *Occult and Scientific Mentalities* (ref. 14), 315-35; and P. M. Rattansi, "Newton's alchemical studies", in Allen G. Debus (ed.), *Science, medicine and society in the Renaissance* (this ref.), ii, 167-82; and Betty Jo Teeter Dobbs, *The foundations of Newton's alchemy* (ref. 14).

<sup>22</sup> The major study is Robert E. Schofield, *Mechanism and materialism: British natural philosophy in an age of reason* (Princeton, 1970). But see also Arnold Thackray, *Atoms and powers: An essay on Newtonian matter-theory and the development of chemistry* (Cambridge, MA, 1970); and P. M. Heimann and J. E. McGuire, "Newtonian forces and Lockean powers: Concepts of matter in eighteenth-century thought", *Historical studies in the physical sciences*, iii (1971), 233-306.

<sup>23</sup> I have argued this elsewhere: John Henry, "Magic and science in the sixteenth and seventeenth centuries", in G. N. Cantor, J.R.R. Christie, J. Hodge, and R.C. Olby (eds), *Companion to the history of modern science* (London and New York, 1990), 583-96; and *The Scientific Revolution and the origins of modern science*, 2<sup>nd</sup> edition (Basingstoke and New York, 2002), 54-67. See also Paolo Rossi, *Francis Bacon* (ref. 15); Charles Webster, *From Paracelsus to Newton* (ref. 15). See also Ann Blair, "Natural philosophy", in Katharine Park and Lorraine Daston (eds), *The Cambridge history of science. Volume 3: Early modern science* (Cambridge, 2006), 365-406, who writes of the "Transformation of natural philosophy by empirical and mathematical methods" but does not explicitly mention the magical tradition as a source of these methods.

<sup>24</sup> Keith Thomas, *Religion and the decline of magic* (London, 1971). For a convenient summary of criticisms of Thomas's theses, and an alternative view, see Alan Macfarlane, "Civility and the decline of magic", in Peter Burke, Brian Harrison, and Paul Slack (eds), *Civil histories: Essays in honour of Sir Keith Thomas* (Oxford, 2000), 145-60. On the continued fortune of magic in popular culture see, for example, Robert Muchembled, *Popular culture and elite culture in France, 1400-1750* (Baton Rouge and London, 1985); and Owen Davies, *Cunning folk: Popular magic in English history* (New York and London, 2003).

<sup>25</sup> For studies of the importance of drawing intellectual or disciplinary boundaries in order to support knowledge claims see, T. F. Gieryn, "Boundary-work and the demarcation of science from non-

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science: Strains and interests in professional ideologies of scientists”, *American sociological review*, 48 (1983), 781-95; and B. Barnes, D. Bloor and J. Henry, *Scientific knowledge: A sociological analysis* (London and Chicago, 1996), 140-68.

<sup>26</sup> I am encouraged in this line of argument by the similar claim made brilliantly with regard to alchemy in Lawrence M. Principe and William R. Newman, “Some problems with the historiography of alchemy”, in W. R. Newman and A. Grafton (eds), *Secrets of nature: Astrology and alchemy in early modern Europe* (Cambridge, MA, 2001), 385-431.

<sup>27</sup> For a discussion of the clear separation, and distance, between two major aspects of what we might think of as a unified magical tradition, astrology and alchemy, see Newman and Grafton (eds), *Secrets of nature* (ref. 26), 14-27.

<sup>28</sup> Stuart Clark, “The scientific status of demonology”, in Vickers (ed.), *Occult and scientific mentalities* (ref. 14), 351-74; idem, *Thinking with demons: The idea of witchcraft in early modern Europe* (Oxford, 1997), 161-79.

<sup>29</sup> Giambattista della Porta, *Natural magick... in twenty books* (London, 1658), Bk I, Ch. 2, p. 2. This popular manual of natural magic was originally published in four books in Naples, 1554, and in twenty books in 1589. For a brief discussion, see Millen, “Manifestation of occult qualities” (ref. 15).

<sup>30</sup> Cornelius Agrippa, *De incertitudine et vanitate omnium scientiarum et artium* (place not given, 1531), chapter 42.

<sup>31</sup> Francis Bacon, *Novum organum*, Pt I, Aphorism IV. On magic in the work of Francis Bacon see Rossi, *Francis Bacon* (ref. 15); and John Henry, *Knowledge is power: Francis Bacon and the method of science* (Cambridge, 2002), 42-81.

<sup>32</sup> Robert Hooke, *Micrographia* (London, 1665), 12, 15, 16, etc.; Isaac Newton, Letter to Robert Boyle, February 28, 1679, in Cohen (ed.), *Newton's papers and letters* (ref. 8), 251. See John Henry, “Robert Hooke, the incongruous mechanist”, in Michael Hunter and Simon Schaffer (eds), *Robert Hooke: New studies* (Woodbridge, Suffolk, 1989), 149-80.

<sup>33</sup> Women and, to a lesser extent, uneducated men were held to be capable of magical knowledge, of course, but usually only to a limited extent. Prejudiced assumptions by the elite about the limits of the knowledge of such “cunning” men and women were to have appalling consequences during the witch crazes. Supposed success in magical operations was assumed to have been achieved thanks to the Devil’s help (rather than by knowledge of natural occult qualities and powers), and so the witch was

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presumed guilty of commerce with Satan. The educated magus would always have been able to defend himself from similar charges by insisting that he used only natural magic, and by demonstrating a clear understanding of the distinction between natural and demonic magic. Uneducated witches were not always able to make such clear distinctions, and much less so during inquisitorial proceedings. On popular knowledge of medicine see John Henry, "Doctors and healers: Popular culture and the medical profession", in Stephen Pumfrey, Paolo Rossi, and Maurice Slawinski (eds), *Science, culture and popular belief in Renaissance Europe* (Manchester, 1991), 191-221. Literature on the witch crazes is vastly extensive, but see, for example, Norman Cohn, *Europe's inner demons: The demonization of Christians in medieval christendom* (Chicago, 1993); Hugh Trevor-Roper, *The European witch-craze of the sixteenth and seventeenth centuries* (Harmondsworth, 1969). Bengt Ankarloo, Stuart Clark, and William Monter (eds), *Witchcraft and magic in Europe: The period of the witch trials* (Philadelphia, 2002).

<sup>34</sup> Agrippa, *De incertitudine et vanitate omnium scientiarum* (ref. 30), chapter 42. See also Lauren Kassell, "'All was that land full fill'd of faerie', or magic and the past in early modern England", *Journal of the history of ideas*, 67 (2006), 107-22, p. 112.

<sup>35</sup> William Eamon, *Science and the secrets of nature: Books of secrets in medieval and early modern culture* (Princeton, 1994); and Bert Hansen, "Science and magic", in D. C. Lindberg (ed.), *Science in the middle ages* (Chicago, 1975), 483-506, pp. 493-5.

<sup>36</sup> Recorded during one of the weekly conferences conducted at Theophraste Renaudot's Bureau d'adresse from 1633 to 1642. Quoted from Kathleen Wellman, "Talismans, incubi, divination and the Book of M\*: The Bureau d'Adresse confronts the occult", in A. G. Debus and Michael T. Walton (eds), *Reading the book of nature: The other side of the Scientific Revolution* (St Louis, 1998), 215-38, p. 228.

<sup>37</sup> Brian Copenhaver, "Did science have a Renaissance?" *Isis*, lxxxiii (1992), 387-407; Michel Foucault, *The order of things: An archaeology of the human sciences* (London, 1974); E. M. W. Tillyard, *The Elizabethan world picture* (London, 1943).

<sup>38</sup> Clark, "Scientific status of demonology" (ref. 28); and idem, *Thinking with demons* (ref. 28), 161-78.

<sup>39</sup> John Cotta, *The triall of witch-craft* (London, 1616), 34.

<sup>40</sup> William Perkins, *Discourse of the damned art of witch-craft* (Cambridge, 1610), 59. The fact that Perkins does not list magicians among those "that are most excellent" in the knowledge of natural

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magic reflects the Church's reluctance to acknowledge anything worthy in magicians (Perkins was an Anglican clergyman). This is discussed more fully below.

<sup>41</sup> James VI, *Daemonologie* (Edinburgh, 1597), 44.

<sup>42</sup> The most notorious example of this kind of short cut to wisdom is provided by John Dee, who thanks to his "scrying stone" and a supposedly psychic "medium", Edward Kelly, who was all too willing to please, held many conversations with angels from 1582 to 1587, with a view to being able to make the philosopher's stone. Note that Dee, for obvious religious reasons, always claimed he was summoning angels, not demons. See Deborah E. Harkness, *John Dee's conversations with angels: Cabala, alchemy, and the end of nature* (Cambridge, 1999).

<sup>43</sup> Perkins, *Discourse of the damned art of witch-craft* (ref. 40), 20.

<sup>44</sup> Agrippa, *De incertitudine et vanitate omnium scientiarum* (ref. 30), chapter 42.

<sup>45</sup> F. Giuntini, *Speculum astronomiae* (Paris, 1573), quoted from Lynn Thorndike, *A History of Magic and Experimental Science*, 8 vols (New York, 1923-58), vi, 132.

<sup>46</sup> See D. P. Walker, *Spiritual and demonic magic from Ficino to Campanella* (London, 1958), 36, 83; Hansen, "Science and magic" (ref. 35), 488-89. As in so many other cases, the Church's attitude forged popular consciousness. Hence, Christopher Marlowe, *The tragical history of Doctor Faustus* (1604), or the less well known Robert Greene, *The honourable historie of Frier Bacon and Frier Bungay* (c. 1592). On the legend of Faust, see E. M. Butler, *The myth of the magus: Ritual magic, and the fortunes of Faust*, 3 vols (Cambridge, 1948, 1949, and 1952). Literature on the witch-crazes is vastly extensive, but see, for example, the works cited in ref. 33 above.

<sup>47</sup> Or some who were more than one of these things—magical traditions featured prominently in Renaissance eclecticism. John Napier, for example, inventor of logarithms, also devoted much of his time to alchemy, and was known locally, in Edinburgh, as a wizard. See Francis Shennan, *Flesh and bones: The life, passions and legacies of John Napier* (Edinburgh, 1989).

<sup>48</sup> A. G. Molland, "Roger Bacon as magician", *Traditio*, xxx (1974), 445-60, p. 459-60. Consider also the revealingly contradictory title of Roger Bacon's *Epistola de secretis operibus artis et naturae, et de nullitate magiae*, written between 1248 and 1267.

<sup>49</sup> For a recent discussion of Naudé's book see Kassell (ref. 34). Molland, "Roger Bacon as magician" (ref. 48), 448.

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<sup>50</sup> Robert Hooke, “Of Dr Dee’s book of spirits” (1690), in Richard Waller (ed.), *The posthumous works of Robert Hooke* (London, 1705), 203-10. See, Henry, “Robert Hooke” (ref. 32), 176-8; Richard Deacon, *John Dee, scientist, geographer, astrologer and secret agent to Elizabeth I* (London, 1968). Dee’s séances with angels had been published in 1659: *A true & faithful relation of what passed for many yeers between dr. John Dee ... and some spirits*, edited by Meric Casuabon (London, 1659). See Harkness, *John Dee’s conversations with angels* (ref. 42). On Trithemius, see Klaus Arnold, *Johannes Trithemius (1462-1516)* (Würtzburg, 1971), and Wayne Shumaker, *Renaissance curiosa* (Binghampton, 1982).

<sup>51</sup> On Bacon’s criticisms of magic see Rossi, *Francis Bacon* (ref. 15), 31-5.

<sup>52</sup> The retraction appeared in a general attack on all human knowledge, and an affirmation of Christian fideism, Cornelius Agrippa, *De incertitudine & vanitate scientiarum declamatio invectiva...* (place unknown, 1530), but has been shown to share the same magico-religious foundations as the *De occulta philosophia*—so much so that the two works are said to share a basic unity. See Michael H. Keefer, “Agrippa’s dilemma: Hermetic rebirth and the ambivalence of *De vanitate* and *De occulta philosophia*”, *Renaissance quarterly*, xli (1988), 614-53.

<sup>53</sup> Newton, *Opticks* (ref. 7), Bk III, Pt I, Query 31, p. 401.

<sup>54</sup> For example, *Opticks* (ref. 7), Queries, 1, 4, 21, 29, and 31, pp. 339, 352, 371, 375-6; Isaac Newton, *The principia. Mathematical principles of natural philosophy*, a new translation by I. B. Cohen and Anne Whitman (Berkeley, 1999), 382-3. On Newton’s alchemy see the works cited in note 15 above. On action at a distance in Newton see Henry, “Pray do not ascribe that notion to me” (ref. 20).

<sup>55</sup> On the sociology of ‘boundary demarcation’ see the works cited in ref. 25 above. We have mentioned the continuing and constant religious objection to demonology, but there was a new development in the late Renaissance and early modern periods, namely a sceptical denial of the existence of demons and other spiritual beings which went hand-in-hand with the rise of atheism, irreligion and secularism. For a general survey of such trends see Richard H. Popkin, *The history of scepticism from Erasmus to Spinoza* (Berkeley, 1979). For the relevance of these developments to the decline of magic, especially demonology, see Michael Hunter, “Witchcraft and the decline of belief”, *Eighteenth-century life*, xxii (1998), 139-47.

<sup>56</sup> See Vickers, “Introduction”, in idem (ed.), *Occult and Scientific Mentalities* (ref. 14), 1-55. Professor Vickers is more sophisticated than the label “positivist” might imply. In a recent essay he has

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distinguished between “occult<sub>1</sub>”, “a neutral distinction between visible and invisible causes”, and “occult<sub>2</sub>”, which is not so clearly defined (he refers to it as a synthesis of “magic and astrology”, a “philosophy in its own right”, and an “aggressive formulation” which led to “an increasingly bitter denunciation of occultism by both the Church and secular scholars”). I can agree that in the process of redefining boundaries there was this kind of bifurcation of the occult, but I see it as a process hinging upon many historical contingencies, while Professor Vickers seems to see it merely as a matter of an ahistorical entity called science, triumphing over an ahistorical entity called magic. See Brian Vickers, “The occult in the Renaissance”, *Annals of science*, lii (1995), 77-84.

<sup>57</sup> Frank L. Borchardt, “The Magus as Renaissance man”, *Sixteenth century journal*, xxi (1990), 57-76, pp. 59, 72.

<sup>58</sup> Literature on the relations between the new philosophies and religion is vast, but for recent provocative insights see Amos Funkenstein, *Theology and the scientific imagination from the Middle Ages to the seventeenth century* (Princeton, 1986); Peter Harrison, *The Bible, Protestantism, and the rise of natural science* (Cambridge: Cambridge University Press, 1998); and Stephen Gaukroger, *The emergence of a scientific culture: Science and the shaping of modernity, 1250-1685* (Oxford, 2006).

<sup>59</sup> In fact there was a short-lived attempt to do just this, and this will be briefly discussed later (see ref. 110 and text at that point). But this was a minor historical episode which serves to highlight the more general trend.

<sup>60</sup> Stuart Clark, “The rational witchfinder: Conscience, demonological naturalism and popular superstitions”, in Pumfrey, Rossi and Slawinski (eds), *Science, culture and popular belief* (ref. 33), pp. 222-48; idem, *Thinking with demons* (ref. 28).

<sup>61</sup> Clark, “Rational witchfinder” (ref. 60); Hansen, “Science and magic” (ref. 35), 488-9. See also Caroline Oates, “Metamorphosis and lycanthropy in Franche-Comté, 1521-1643”, in M. Feher (ed.), *Fragments for a history of the human body, Part One* (New York, 1989), 305-63, especially p. 320.

<sup>62</sup> Clark, “Rational witchfinder” (ref. 60).

<sup>63</sup> Ibid.

<sup>64</sup> Literature on the witch-crazes is dauntingly vast, but see, for example, Christina Larner, *Witchcraft and religion: The politics of popular belief* (Oxford, 1984); Joseph Klaitz, *Servants of Satan: the age of the witch hunts* (Bloomington, 1985); Jonathan Barry, Marianne Hester and Gareth Roberts (eds), *Witchcraft in early modern Europe: Studies in culture and belief* (Cambridge, 1996); Robin Briggs,

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*Witches and neighbours: The social and cultural context of European witchcraft* (London, 1996); and the works cited in ref. 33 above.

<sup>65</sup> Michael Hunter, “Alchemy, magic and moralism in the thought of Robert Boyle”, in idem, *Robert Boyle (1627-91): Scrupulosity and science* (Woodbridge, Suffolk, 2000), 93-118. See also idem (ed.), *Robert Boyle by himself and his friends* (London, 1994).

<sup>66</sup> See Hunter, *Boyle by himself* (ref. 65), 29-31.

<sup>67</sup> Quoted from Michael Hunter, “Alchemy, magic and moralism” (ref. 65), 116.

<sup>68</sup> For detailed expositions of what has come to be called the scholar and craftsman thesis, see Edgar Zilsel, *The social origins of modern science* (Dordrecht, 2000); and Pamela H. Smith, *The body of the artisan: Art and experience in the Scientific Revolution* (Chicago, 2004); and idem, “Laboratories”, in Park and Daston (eds), *Cambridge history of science. Volume 3* (ref. 23), 290-319.

<sup>69</sup> Foster Watson, *Vives: On education. A translation of the De tradendis disciplinis, together with an introduction* (Cambridge, 1913), 209. On Vives, see Carlos G. Noreña, *Juan Luis Vives* (The Hague, 1970). Francis Bacon, *New organon*, Part II, Aphorism 31.

<sup>70</sup> On Gilbert, see John Henry, “Animism and empiricism: Copernican physics and the origins of William Gilbert’s experimental method”, *Journal of the history of ideas*, lxii (2001), 99-119; on Boyle as a thoroughgoing alchemist, rather than one who turned to it later, see Lawrence Principe, *The aspiring adept: Robert Boyle and his alchemical quest* (Princeton, 1998); and William Newman, *Atoms and alchemy* (ref. 16).

<sup>71</sup> Arthur C. Clarke, *Profiles of the future: An inquiry into the limits of the possible* (London, 1962).

<sup>72</sup> Salluste du Bartas, *His divine weekes and workes*, translated by J. Sylvester (London, 1606), 221; quoted from J. Peter Zetterberg, “The mistaking of ‘the mathematicks’ for magic in Tudor and Stuart England”, *Sixteenth Century Journal*, xi (1980), 83-97, p. 93. On superstitious beliefs about mathematics and magic and demonology, see Mordechai Feingold, “The occult tradition in the English universities of the Renaissance: A reassessment”, in Vickers (ed.), *Occult and scientific mentalities* (ref. 14), 73-94; and Katherine Neal, “The rhetoric of utility: Avoiding occult associations for mathematics through profitability and pleasure”, *History of science*, xxxvii (1999), 151-78.

<sup>73</sup> See, Thorndike, *History of magic and experimental science* (ref. 45); M. Sherwood, “Magic and mechanics in medieval fiction”, *Studies in philology*, xli (1947), 567-92; Zetterberg, “The mistaking of ‘the mathematicks’ for magic” (ref. 72); William Eamon, “Technology as magic in the late middle ages

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and the Renaissance”, *Janus*, (1983), 171-212; A. George Molland, “Cornelius Agrippa’s mathematical magic”, in Cynthia Hay (ed.), *Mathematics from manuscript to print* (Oxford, 1988), 209-19; Henry, “Magic and science” (ref. 23).

<sup>74</sup> See, for example, Paul Lawrence Rose, *The Italian Renaissance of mathematics: Studies on humanists and mathematicians from Petrarch to Galileo* (Geneva, 1975); Robert S. Westman, “The astronomer’s role in the sixteenth century: A preliminary survey”, *History of science*, xviii (1980), 105-47; Nicholas Jardine, “Epistemology of the sciences”, in C. B. Schmitt and Q. Skinner (eds), *The Cambridge history of Renaissance philosophy* (ref. 15), 685-711; Mario Biagioli, “The Social Status of Italian Mathematicians, 1450-1600”, *History of science*, xxvii (1989), 41-95; J. A. Bennett, ‘The challenge of practical mathematics’, in Pumfrey, Rossi and Slawinski (eds), *Science, culture and popular belief* (ref. 33), 176-90; Anna De Pace, *Le matematiche e il mondo: Ricerche su un dibattito in Italia nella seconda metà del cinquecento* (Milan, 1993); James M. Lattis, *Between Copernicus and Galileo: Christoph Clavius and the collapse of Ptolemaic cosmology* (Chicago, 1994); Peter Dear, *Discipline and experience: The mathematical way in the Scientific Revolution* (Chicago, 1995).

<sup>75</sup> Zetterberg, “The mistaking of ‘the mathematicks’ for magic” (ref. 72). For more positivist tendencies in the history of Renaissance mathematics see Edward W. Strong, *Procedures and metaphysics: A study in the philosophy of mathematical-physical science in the sixteenth and seventeenth centuries* (Berkeley, 1936).

<sup>76</sup> On Napier, see Mark Napier, *Memoirs of John Napier of Merchiston: His lineage, life, and times, with a history of the invention of logarithms* (Edinburgh, 1834); and Shennan, *Flesh and bones* (ref. 47). Napier’s alchemy remains largely unstudied, but see J. Small, “Sketches of later Scottish alchemists: John Napier of Merchiston, Robert Napier, Sir David Lindsay, first earl of Balcarres, Patrick Ruthven, Alexander Seton, and Patrick Scot”, *Proceedings of the Society of Antiquaries of Scotland*, xi (1874–6), 410–38. His alchemical papers are in Edinburgh University Library. Literature on Dee is extensive. See Stephen Clucas, “Recent Works on John Dee (1988-2005): A Select Bibliography”, in idem (ed.), *John Dee: Interdisciplinary Studies in English Renaissance Thought* (Dordrecht, 2006), 345-50. The best single study is Nicholas H. Clulee, *John Dee’s natural philosophy: Between science and religion* (London and New York, 1988).

<sup>77</sup> John Wilkins, *Mathematical magick, or, the wonders that may be performed by mechanical geometry* (London, 1648). The major study is still Barbara Shapiro, *John Wilkins: An intellectual biography*



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(Berkeley, 1969), but see also, Ana Maria Alfonso-Goldfarb, “An ‘older’ view about matter in John Wilkins’ ‘modern’ mathematical magick”, in A. G. Debus and M. T. Walton (eds), *Reading the book of nature* (ref. 36), 133-46.

<sup>78</sup> René Descartes, *Principia philosophiae*, IV, §203. On the impact of the pseudo-Aristotelian *Quaestiones mechanicae*, see Helen Hattab, “From mechanics to mechanism: The *Quaestiones mechanicae* and Descartes’ physics”, in Peter R. Anstey and John A. Schuster (eds), *The science of nature in the seventeenth century: Patterns of change in early modern natural philosophy* (Dordrecht, 2005), 99-129.

<sup>79</sup> This book has been translated into English: Girolamo Cardano, *De subtilitate, book 1*, translated, with introduction and notes, by Myrtle Marguerite Cass (Williamsport, Pa., 1934). The best edition of the *De subtilitate*, (currently only the first seven books) is *De subtilitate libri XXI (Libri I-VII)*, edizione critica a cura di Elio Nenci (Milan, 2004). For studies of Cardano see Angelo Bellini, *Girolamo Cardano e il suo tempo* (Milan, 1947); Nancy G. Siraisi, *The clock and the mirror: Girolamo Cardano and Renaissance medicine* (Princeton, 1997); and Anthony Grafton, *Cardano's cosmos: The worlds and works of a Renaissance astrologer* (Cambridge, MA, 1999). See also Girolamo Cardano, *De libris propriis: The editions of 1544, 1550, 1557, 1562*, edited by Ian Maclean (Milan, 2004).

<sup>80</sup> Jens Høyrup, “Philosophy: Accident, epiphenomenon, or contributory cause of the changing trends of mathematics—a sketch of the development from the twelfth through the sixteenth century”, in idem, *In measure, number, and weight: Studies in mathematics and culture* (Albany, 1994), 123-71, p. 165, see also pp. 154-6. See also William R. Newman, *Promethean ambitions: Alchemy and the quest to perfect nature* (Chicago, 2004).

<sup>81</sup> See McGuire and Rattansi, “Newton and the ‘Pipes of Pan’” (ref. 12). Consider also, in this connection, Ayval Leshem, *Newton on mathematics and spiritual purity* (Dordrecht, 2003).

<sup>82</sup> For the details of Kepler’s geometrical archetype see Alexandre Koyré, *The astronomical revolution: Copernicus, Kepler, Borelli*. Translated by R. E. W. Maddison (London, 1973); J. V. Field, *Kepler's geometrical cosmology* (London, 1988); and Rhonda Martens, *Kepler's philosophy and the new astronomy* (Princeton, 2000).

<sup>83</sup> Kepler and Fludd engaged in a dispute, played out in dauntingly long publications, on the issue of numerology. See Robert S. Westman, “Nature, art, and psyche: Jung, Pauli, and the Kepler-Fludd

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polemic”; and J. V. Field, “Kepler’s rejection of numerology”, both in Vickers (ed.), *Occult and scientific mentalities* (ref. 14), 177-229, and 273-96, respectively.

<sup>84</sup> Principe and Newman, “Some problems with the historiography of alchemy” (ref. 26). See also, Lawrence M. Principe, “Reflections on Newton’s alchemy in light of the new historiography of alchemy”, in J. E. Force and S. Hutton (eds), *Newton and Newtonianism: New studies* (Dordrecht, 2004), 205-19.

<sup>85</sup> Ibid., 386. See also W. R. Newman and L. M. Principe, “Alchemy vs. chemistry: The etymological origins of a historiographic mistake”, *Early science and medicine*, iii (1998), 32-65.

<sup>86</sup> Principe and Newman “Some problems with the historiography of alchemy” (ref. 26), 418.

<sup>87</sup> Ibid., 413-5. The principle contributor to this new scholarship is William Newman himself. See, for a recent example, William Newman, *Atoms and alchemy* (ref. 16).

<sup>88</sup> William B. Ashworth jr., “Natural history and the emblematic world view”, in David C. Lindberg and Robert S. Westman (eds), *Reappraisals of the Scientific Revolution* (Cambridge, 1980), 303-32. See also, James J. Bono, *The word of God and the languages of man: Interpreting nature in early modern science and medicine* (Madison, 1995); and Harrison, *The Bible, Protestantism, and the Rise of Natural Science* (ref. 58). But see also Ann Blair, “*Historia* in Zwinger’s *Theatrum humanae vitae*”, in Gianna Pomata and Nancy G. Siraisi (eds), *Historia: Empiricism and erudition in early modern Europe* (Cambridge, Mass, 2005), 269-96.

<sup>89</sup> On these new occultist developments in medicine see Linda Deer Richardson, “The generation of disease: Occult causes and diseases of the total substance”, in A. Wear, R. K. French and I. M. Lonie (eds), *The medical renaissance of the sixteenth century* (Cambridge, 1985), 175-94; and John Henry and John M. Forrester, “Jean Fernel and the importance of his *De abditis rerum causis*”, in idem, *Jean Fernel’s On the hidden causes of things: Forms, souls and occult diseases in Renaissance medicine* (Leiden, 2005), 37-44.

<sup>90</sup> Jean Fernel, *De abditis rerum causis* (Paris, 1648), Bk II, Ch. 16. For a new edition and translation of this important work see Forrester and Henry, *Jean Fernel’s On the hidden causes of things* (ref. 89); on amulets, see 646-73.

<sup>91</sup> Johann Wier, *De praestigiis daemonum...* (Basel, 1583), Bk V, Ch. 8, column 535, quoted from Walker, *Spiritual and demonic magic* (ref. 46), 154; and, of course, Genesis, 1, 3.

<sup>92</sup> See Hansen, “Science and magic” (ref. 35), 488.

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<sup>93</sup> M. M. Slaughter, *Universal languages and scientific taxonomy in the seventeenth century* (Cambridge, 1982); and Paolo Rossi, *Logic and the art of memory: The quest for a universal language*, translated by Stephen Clucas (London, 2000).

<sup>94</sup> Francis Bacon, *Valerius Terminus*, and ‘Proemium’ to *Great instauration*, in John M. Robertson (ed.), *Philosophical works of Francis Bacon* (London, 1905), 188, and 241 respectively. John Wilkins, *Essay towards a real character and a philosophical language* (London, 1668).

<sup>95</sup> On the historical phenomenon of Christian cabbalism see Joseph Leon Blau, *The Christian interpretation of the Cabala in the Renaissance* (New York, 1944); and Moshe Idel, “The magical and Neoplatonist interpretation of the Kabbalah in the Renaissance”, in B. D. Cooperman (ed.), *Jewish Thought in the Sixteenth Century* (Cambridge, Mass, 1983), 186-242. On Giovanni Pico see S. A. Farmer, *Syncretism in the West. Pico's 900 theses (1486): The evolution of traditional, religious, and philosophical systems*; with text, translation, and commentary (Tempe, Arizona: Medieval & Renaissance Texts & Studies, 1998). On Leibniz’s efforts to develop a universal language and the role of cabbalism in these schemes, see Allison P. Coudert, “Some theories of a natural language from the Renaissance to the seventeenth century”, *Studia Leibnitiana*, vii (1978), 119-41; idem, “Forgotten ways of knowing: The Kabbalah, language, and science in the seventeenth century”, in Donald R. Kelley and R. H. Popkin (eds), *The shapes of knowledge: From the Renaissance to the Enlightenment* (Dordrecht, 1991), 83-99; and Rossi, *Logic and the art of memory* (ref. 93).

<sup>96</sup> Guy de la Brosse (1628) and John Ray (1660) both quoted from Brian Vickers, “Critical reactions to the occult sciences during the Renaissance”, in E. Ullmann-Margalit (ed.), *The scientific enterprise* (Dordrecht, 1992), 43-92, pp. 77-79.

<sup>97</sup> For a recent convenient summary of the Renaissance arguments against astrology, see Brian Vickers, “Critical reactions to the occult sciences during the Renaissance” (ref. 96). But see also, Jim Tester, *A history of Western astrology* (Woodbridge, 1987); Eugenio Garin, *Astrology in the Renaissance: The zodiac of life* (London, 1983); and H. Darrel Rutkin, “Astrology”, in Park and Daston (eds), *The Cambridge history of science. Volume 3* (ref. 23), 542-61.

<sup>98</sup> Johannes Kepler, *Mysterium cosmographicum* (1597), in *Gesammelte Werke*, i (Munich, 1938), 21. Galileo, always loath to accept magical influence, did deny the effect of the Moon on the tides. On this issue, however, the magicians were correct and Galileo was embarrassingly wrong. Galileo Galilei,

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*Dialogue on the two chief world systems*, translated by Stillman Drake (New York, 2001), Fourth Day, 487.

<sup>99</sup> See, J. V. Field, “Astrology in Kepler’s cosmology”, in Patrick Curry (ed.), *Astrology, science and society* (Woodbridge, 1987), 143-70; and idem, “A Lutheran astrologer: Johannes Kepler”, *Archive for history of exact sciences*, xxxi (1984), 189-272 (which includes a complete translation of *De fundamentis astrologiae certioribus*).

<sup>100</sup> Vickers, “Critical reactions to the occult sciences” (ref. 96), Tester, *A history of Western astrology* (ref. 97).

<sup>101</sup> On empirical investigations of astrology and the weather see Michael Hunter and Annabel Gregory, *An astrological diary of the seventeenth century: Samuel Jeake of Rye, 1652-1699* (Oxford, 1988), Michael Hunter, “Science and astrology in seventeenth-century England: An unpublished polemic by John Flamsteed”, in Curry (ed.), *Astrology, science and society* (ref. 99), 261-300.

<sup>102</sup> P. de Maupertuis, “Lettre sur la comete”, in *Oeuvres* (Lyons, 1768), iii, 209-56, p. 240. Quoted from Simon Schaffer, “Newton’s comets and the transformation of astrology”, in Curry (ed.), *Astrology, science and society* (ref. 99), 219-43, p. 237.

<sup>103</sup> Edmund Halley, “Some considerations about the cause of the universal deluge”, *Philosophical transactions*, xxxiii (1724), 118-25; and William Whiston, *Vindication of the new theory of the Earth* (London, 1698), Preface; both quoted from Schaffer, “Newton’s comets” (ref. 103), 233.

<sup>104</sup> Newton’s belief recorded by his friend John Craig, Cambridge University Library, Keynes MS 130.7, f. 1r. See also Isaac Newton, “De gravitatione et aequipondio fluidorum”, in A. R. Hall and M. B. Hall (eds), *Unpublished scientific papers of Isaac Newton* (Cambridge, 1962), 139.

<sup>105</sup> The rivalry on this issue between Newton and Leibniz is brought out most starkly in the so-called Leibniz-Clarke correspondence. See, H. G. Alexander (ed.), *The Leibniz-Clarke correspondence* (Manchester, 1956); Ezio Vailati, *Leibniz and Clarke: A study of their correspondence* (Oxford, 1997). For an account of the role of comets in Newton’s system see, David Kubrin, “Newton and the cyclical cosmos”, *Journal of the history of ideas*, xxviii (1967), 325-46; and Sara Schechner Genuth, “Comets, teleology and the relationship of chemistry to cosmology in Newton’s thought”, *Annali dell’Istituto e museo di storia della scienza di Firenze*, x (1985), 31-65; and Schaffer, “Newton’s comets” (ref. 103).

<sup>106</sup> Two developments summed up by Pierre Simon Laplace, author of *Traité du mécanique céleste*, 5 vols (1799-1825), who used Newtonian mechanics to show that the planetary system was self-

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regulating, without the need for comets, and who also told Napoleon that God was not mentioned in his book because he “had no need of that hypothesis”. See C. C. Gillispie, *Pierre-Simon Laplace, 1749-1827: A life in exact science* (Princeton, 1997).

<sup>107</sup> Petrus Peregrinus Maricurtensis, *De magnete, seu rota perpetui motus, libellus... nunc primum promulgatus* (Augsburg, 1558). See S. P. Thompson, *The epistle of Peter Peregrinus de Maricourt to Sygerus de Foucaucourt, soldier, concerning the magnet* (London: for the author, 1902); and H. D. Harradon, “Some early contributions to the history of geomagnetism—I: The letter of Peter Peregrinus de Maricourt to Sygerus de Foucaucourt, soldier, concerning the magnet,” *Terrestrial magnetism and atmospheric electricity*, xlviii (1943), 3-17. William Gilbert, *De magnete* [1600], translated by P. Fleury Mottelay (New York, 1958). For details see Henry, “Animism and empiricism” (ref. 70). For a general study of the concept of self-movement in Aristotelianism see Mary Louise Gill and James G. Lennox (eds), *Self-movement: From Aristotle to Newton* (Princeton, 1994).

<sup>108</sup> J. A. Bennett, “Magetical philosophy and astronomy from Wilkins to Hooke,” in R. Taton and C. Wilson (eds), *Planetary astronomy from the Renaissance to the rise of astrophysics, Part A: Tycho Brahe to Newton* (Cambridge, 1989), 222-30. On Kepler’s use of Gilbert see, for example, Alexandre Koyré, *The astronomical revolution* (ref. 82), 185-214.

<sup>109</sup> Sir William Petty, *The discourse made before the Royal Society... together with a new hypothesis of springing or elastique motions* (London, 1674). See Henry, “Occult qualities and the experimental philosophy (ref. 15), 350-51.

<sup>110</sup> Moody E. Prior, “Joseph Glanvill, witchcraft and seventeenth-century science”, *Modern philology*, xxx (1932), 167-93; George Edelin, “Joseph Glanvill, Henry More, and the phantom drummer of Tedworth”, *Harvard Library Bulletin*, x (1956), 186-92; Thomas Harmon Jobe, “The devil in Restoration science: The Glanvill-Webster debate”, *Isis*, lxxii (1981), 343-56; and Ian Bostridge, *Witchcraft and its transformations c. 1650–c. 1750* (Oxford, 1997). On similar efforts in the Netherlands see Andrew Fix, *Fallen angels: Balthasar Bekker, spirit belief and confessionism in the seventeenth-century Dutch Republic* (Dordrecht, 1999).

<sup>111</sup> It is like comparing Wilkins, *Mathematical magick* (ref. 77), with, say, Petrus Severinus, *Idea medicinae philosophicae: fundamenta continens totius doctrinae Paracelsicae, Hippocraticae, & Galenicae* (Basle, 1571).

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<sup>112</sup> But remember what was said earlier about the possibility that the work of other numerologists on the Keplerian or Newtonian model might simply be being overlooked.

<sup>113</sup> The main support for the claim that experimentalism and the utilitarianism of the new philosophies derives from the occult tradition is to be found in Francis Bacon. See Rossi, *Francis Bacon: From magic to science* (ref. 15); Henry, *Knowledge is power* (ref. 31). But see also, for example, Henry, "Magic and science" (ref. 23); idem, "Occult qualities and the experimental philosophy" (ref. 15), and idem, "Animism and empiricism" (ref. 70).

<sup>114</sup> On the decline of belief in symbolic magic see Brian Vickers, "Analogy versus identity: The rejection of occult symbolism, 1580-1680, in idem (ed.), *Occult and scientific mentalities* (ref. 14); and idem, "Critical reactions to the occult sciences" (ref. 96). See also, Brian Copenhaver, "The occultist tradition and its critics", in D. Garber and M. Ayers (eds), *The Cambridge history of seventeenth-century philosophy* (Cambridge, 1998), 454-512.

<sup>115</sup> Walker, *Spiritual and demonic magic* (ref. 46), 84; Thomas, *Religion and the decline of magic* (ref. 24); and Clark, "The rational witchfinder" (ref. 60).

<sup>116</sup> The literature here is vast but an obvious starting point is Keith Thomas, *Religion and the decline of magic* (ref. 24). Consider also, Clark, *Thinking with demons* (ref. 28). On the socio-political dimensions of alchemy, which has been well served in the literature, see for example, P. M. Rattansi, "Paracelsus and the Puritan revolution", *Ambix*, xi (1963), 24-32; Hugh Trevor-Roper, "The Paracelsian movement", in idem, *Renaissance essays* (London, 1985), 149-99; J. Andrew Mendelsohn, "Alchemy and politics in England", *Past and present*, cxxxv (1992), 30-78; and William Newman, "From alchemy to 'chymistry'", in Park and Daston (eds), *The Cambridge history of science. Volume 3* (ref. 23), 497-517. On the political dimension to astrology, see for example, Patrick Curry, *Prophecy and power: Astrology in early modern England* (Oxford, 1989). See also, for another example, Paola Zambelli, "Magic and radical reformation in Agrippa of Nettesheim", *Journal of the Warburg and Courtauld Institutes*, xxxix (1976), 69-103.

<sup>117</sup> Consider, for example, Thomas Digges, *A perfit description of the caelestiall orbes, according to the most auncient doctrine of the Pythagoreans* (London, 1576). On this tradition, usually called the *prisca theologia* tradition, consult Charles B. Schmitt, "Prisca theologia e philosophia perennis: due temi del Rinascimento italiano e la loro fortuna", in *Atti del V Convegno internazionale del Centro di Studi Umanistici: Il pensiero italiano del Rinascimento e il tempo nostro* (Florence, 1970), 211-36; and

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D. P. Walker, *The ancient theology: Studies in Christian Platonism from the fifteenth to the eighteenth century* (London, 1972).

<sup>118</sup> *De vita coelitus comparanda* was the third part of Ficino's *De vita triplici* (Florence, 1489). The meaning of the title is obscure, possibly something like: "On arranging one's life in accordance with the heavens". See Walker, *Spiritual and demonic magic* (ref. 46), 58, where Walker makes it clear that 'spiritual magic' is his own phrase to describe Ficino's ideas. For an indication of Ficino's immense influence see, for example, Hiro Hirai, *Le concept de semence dans les theories de la matière à la renaissance: De Marsile Ficin à Pierre Gasendi* (Turnhout, 2005).

<sup>119</sup> See, Eugenio Garin, "The philosopher and the magus", in idem (ed.), *Renaissance characters*, translated by Lydia G. Cochrane (Chicago, 1997), 123-53. See also, Borchardt, "The magus as Renaissance man" (ref. 57). We should also remember, however, that even a highly learned magician such as Agrippa might call himself a magus and at the same time be anxious about the religious implications of being a magus. See Keefer, "Agrippa's dilemma" (ref. 52)

<sup>120</sup> The most convenient source on the religious *Corpus Hermeticum*, which includes an invaluable introduction, is Brian P. Copenhaver, *Hermetica: The Greek Corpus Hermeticum and the Latin Asclepius in English translation* (Cambridge, 1991). On the so-called "technical" writings see A.-J. Festugière, *La révélation d'Hermès Trismégiste*, Vol. 1: *L'Astrologie et les sciences occultes* (Paris, 1950). For brief assessments of the historical significance of the Hermetic writings see Copenhaver, "Astrology and magic" (ref. 15), idem, "Natural magic, Hermetism, and occultism in early modern science" (ref. 15); and idem, "Magic", in Park and Daston, *Cambridge history of science. Volume 3* (ref. 23), 518-40.

<sup>121</sup> Copenhaver, "Astrology and magic" (ref. 15); idem, "Did science have a Renaissance?" (ref. 37); Walker, *Spiritual and demonic magic* (ref. 46).

<sup>122</sup> Copenhaver, "Astrology and magic" (ref. 15), 273.

<sup>123</sup> For an important study of the role of discussions of natural powers and the abilities of demons see Newman, *Promethean ambitions* (ref. 80).

<sup>124</sup> On Paracelsus see, for example, Walter Pagel, *Paracelsus: An introduction to philosophical medicine in the era of the Renaissance* (Basle, 1958); A. Weeks, *Paracelsus: Speculative theory and the crisis of the early Reformation* (Albany, 1997). On Fracastoro, see Vivian Nutton, "The seeds of disease: An explanation of contagion and infection from the Greeks to the Renaissance." *Medical*

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*History*, xxvii (1983), 1-34; and idem, “The reception of Fracastoro’s theory of contagion: The seed that fell among thorns?” *Osiris*, Second Series, vi (1990), 196-234. On Fernel, see Richardson, “Generation of Disease” (ref. 89); Laurence Brockliss and Colin Jones, *The Medical World of Early Modern France* (Oxford, 1997); Hiroshi Hirai, “Humanisme, néoplatonisme et *prisca theologia* dans le concept de semence de Jean Fernel”, *Corpus*, xli (2002), 43-69; D. P. Walker, “The astral body in Renaissance medicine”, *Journal of the Warburg and Courtauld Institutes*, xxi (1958), 119-33; idem, “Medical spirits in philosophy from Ficino to Newton”, in *Arts du spectacle et histoire des idées* (Tours, 1984), 287-300; and Henry and Forrester, “Jean Fernel and the importance of his *De abditis rerum causis*” (ref. 89).

<sup>125</sup> For brief accounts of the nature of alchemy see Bruce T. Moran, *Distilling knowledge: Alchemy, chemistry, and the Scientific Revolution* (Cambridge, 2005); Newman, *Atoms and alchemy* (ref. 16); and idem, “From alchemy to ‘chymistry’” (ref. 116). On occult qualities see Keith Hutchison, “What happened to occult qualities in the Renaissance?” *Isis*, lxxiii (1982), 233-53; and Millen, “Manifestation of occult qualities”, (ref. 15).

<sup>126</sup> Copenhaver, “Astrology and Magic” (note 15).

<sup>127</sup> On this aspect of Aristotelianism see, for example, Peter Dear, *Discipline and experience* (ref. 74), 11-31; and idem, “The meanings of experience”, in Park and Daston (eds), *Cambridge history of science. Volume 3* (ref. 23), 106-31

<sup>128</sup> On Pomponazzi see, Walker, *Spiritual and demonic magic* (ref. 46), 107-11. On Fernel: Henry and Forrester, “Jean Fernel and the importance of his *De abditis rerum causis*” (ref. 89). On Sennert, see Newman, *Atoms and alchemy* (ref. 16). For general studies of this theme see Millen, “Manifestation of occult qualities” (ref. 15); and Henry, “Magic and science” (ref. 23).

<sup>129</sup> For more details see Newman, *Atoms and alchemy* (ref. 16). See also Lynn S. Joy, “Scientific Explanation from Formal Causes to Laws of Nature”, in Park and Daston (eds), *Cambridge history of science. Volume 3* (ref. 23), 70-105; and Andrew G. van Melsen, *From atomos to atom: The history of the concept atom* (New York, 1960).

<sup>130</sup> Brian Vickers, “Introduction”, in idem (ed.), *Occult and scientific mentalities* (ref. 14), 1-55.

<sup>131</sup> Lauren Kassell, *Medicine and magic in Elizabethan London: Simon Forman, astrologer, alchemist, and physician* (Oxford, 2005). On Fludd, consider, for example, William H. Huffman, *Robert Fludd and the end of the Renaissance* (London and New York, 1988); and Allen G. Debus, *Man and nature in*



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*the Renaissance* (Cambridge, 1978), 121-26. Fludd's work has even been considered alongside that of Agrippa and Cardano: Silvia Parigi, *La magia naturale nel Rinascimento: testi di Agrippa, Cardano, Fludd* (Turin, 1989).

<sup>132</sup> Both Daniel Garber and Lynn S. Joy acknowledge the role of chemical ideas in early modern changes in natural philosophy. See Daniel Garber, "Physics and foundations", and Lynn S. Joy, "Scientific explanation from formal causes to laws of nature", in Park and Daston (eds), *Cambridge history of science. Volume 3* (ref. 23), 29-33, and 70-105, respectively.

<sup>133</sup> See Henry and Forrester, "Jean Fernel and the importance of his *De abditis rerum causis*" (ref. 89); Sylvain Matton, "Fernel et les alchimistes", *Corpus*, xli (2002), 135-97; Nutton, "The seeds of disease" (ref. 124); and idem, "The reception of Fracastoro's theory of contagion" (ref. 124). As representative of the Paracelsians, consider Severinus: Jole Shackelford, *A philosophical path for Paracelsian medicine: The ideas, intellectual context, and influence of Petrus Severinus (1540/2-1602)* (Copenhagen, 2004).

<sup>134</sup> Girolamo Fracastoro, *De sympathia et antipathia rerum* (Lyons, 1554). Girolamo Cardano, *De subtilitate libri XXI* (Basle, 1554). The book mentioned is Book XVIII, but is by no means the only book where Cardano draws upon occult ideas and attitudes.

<sup>135</sup> Bernardino Telesio, *De rerum natura iuxta propria principia libri IX* (Naples, 1587). For Telesio's, Campanella's and even Bacon's credentials as magicians, see Walker, *Spiritual and demonic magic* (ref. 46), 189-93, 199-203, and 203-36. On Bacon's semi-Paracelsian cosmology see, Graham Rees, "Francis Bacon's semi-Paracelsian cosmology", *Ambix*, xxii (1975), 81-101; and idem, "Francis Bacon's semi-Paracelsian cosmology and the Great Instauration", *Ambix*, xxii (1975), 161-73.

<sup>136</sup> On Bruno, see (of course) Frances Yates, *Giordano Bruno and the Hermetic tradition* (London, 1964). Francesco Patrizi, *Nova de universis philosophia libris quinquaginta comprehensa* (Venice, 1593); and *Magia philosophia... Zoroaster et eius cccxx Oracula Chaldaica... Hermetis Trismegisti Poemander...* (Hamburg, 1593).

<sup>137</sup> Henry, "Occult qualities" (ref. 15).