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Edited by J. V. Field and Frank A. J. L. James
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Introduction

J. V. FIELD AND FRANK A. J. L. JAMES

The essays in this volume are concerned with the history of science in Europe between, roughly, 1400 and 1750. Consequently, the adjective 'scientific' hovers behind the nouns 'Renaissance' and 'Revolution' in the title.

The terms 'Renaissance' and 'Scientific Revolution' are both recommended to be used with some degree of circumspection by the most direct heirs of the intellectual communities that gave them birth – that is, cultural historians and historians of science. Both terms, indeed, tend to be applied to periods defined in terms of their intellectual products, somewhat in the manner in which the Bronze Age is defined by the nature of its material artefacts. This form of definition has the advantage of not imposing a spurious unity on the products of a particular time or a particular place.

In combining two such fluid terms in the title of this book we are asking for trouble. We are not, however, asking for lingering reflections upon the meaning of the terms themselves. The trouble takes the form of stirring up the two terms together to see whether the result looks historically interesting. The emphasis is thus on continuing processes rather than on abrupt and tongue-twisting '*gestalt*-switches'. We believe that the terms 'Renaissance' and 'Scientific Revolution' both denote real historical phenomena, but not short, sharp ones well-defined in number, measure and weight. 'Revolution' in particular has shown itself to be sufficiently complex to form the subject of a recent book, whose author, I. B. Cohen, points out that the word itself was not used by the natural philosophers historians now most readily identify as having done revolutionary work.[1] The Renaissance is, of course, by now well accepted as

[1] I. B. Cohen, *Revolution in Science* (Cambridge MA, 1985). The comment about 'revolution' not being an actors' category in the sixteenth and seventeenth centuries is on page 6. G. E. R. Lloyd, *The Revolutions of Wisdom: Studies in the Claims and Practice of Ancient Greek Science* (Berkeley, 1987), which deals with the Ancient World, uses the word 'revolution' in its title but does not include it in the index, or discuss its meaning in connection with references to Kuhn (all of which are very brief). In fact, Lloyd appears to regard the use of 'revolution' as unproblematic for the period with which he is concerned. There is, of course, no question of its being mistaken for an actors' category in this context.

A discussion of the use of the term 'Scientific Revolution' is given in D. C. Lindberg, 'Conceptions of the Scientific Revolution from Bacon to Butterfield: A preliminary sketch', in D. C. Lindberg and R. S. Westman (eds.), *Reappraisals of the Scientific Revolution* (Cambridge, 1990), 1–26. For Rupert Hall's reflections on the term, see below, pp. 239–49.

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having been a rebirth so slow and ill-defined as to allow adequate freedom to the most incompetent astrologer in drawing up its horoscope.[2] Both 'Renaissance' and 'Scientific Revolution' are, moreover, misnomers to the extent that 'What was reborn in the Renaissance?' makes an ideal question for university entrants but is conceivable for an older scholar only on a highly festive occasion, while the Scientific Revolution, if seen as culminating and essentially completed in the work of Newton, resulted in something better described as a mathematized natural philosophy than as 'Science' in today's sense of the word. If one borrows the logical style of Lewis Carroll's Alice and demands that the product of the Scientific Revolution shall be Science, then this book may well need extending to the year 2001.[3] For our present purposes, we are taking the period of the Scientific Revolution as ending in the mid eighteenth century, while bearing in mind that the changes that characterize the Scientific Revolution were not all completed by that time.

The contributors vary widely in the extent to which they engage explicitly with questions of historiography. However, in view of the Carrollian problem mentioned above, we exercised editorial jurisdiction – in no case extending beyond *territio* – over the use of the words 'science' and 'scientist'. In all cases where any uncertainty might be supposed possible, we prescribed the use of 'actors' categories' in the limited sense that the words used should be those that might have been used by participants in the events concerned.[4] The one apparent exception confirms our rule: Westfall's subject made it inevitable that he should use 'science' and 'scientist' in the way he does, and we are sure his usage will not give rise to confusion.

Westfall's is a general study of the scientific community, within wide bounds of space and time. Nutton and Gabbey have written similarly general studies. Most other contributors have dealt with more 'local' subjects, that is, they have concentrated on one particular time and place or one particular figure. For instance, Eamon on Leonardo Fioravanti, Hunter on Robert Boyle, Figala and Petzold on Newton and Yworth, Home on Newton. As will be clear, our use of the term 'local' is not meant to indicate that such studies have no implications beyond the subject with which they are primarily concerned. Such a position would, in any case, be untenable in regard to a

[2] Something of the character of the term is apparent even in the title of Erwin Panofsky's classic *Renaissance and Renascences in Western Art*, first published in 1960. For a historiographic assessment see A. Chastel (ed.), *The Renaissance: Essays in Interpretation* (London, 1982, first published in Italian, 1979). Our use of the term 'Renaissance' in the context of science is, of course, intended as a reference to the title of Marie Boas Hall, *The Scientific Renaissance, 1450–1630* (Cambridge, 1962).

[3] Elements that might be construed as hinting at the possibility of such a conception are to be found in A. Cunningham, 'How the *Principia* got its name; or, taking natural philosophy seriously', *Hist. Sci.*, 1991, **29**: 377–92. Our choice of the year 2001 refers to Arthur C. Clarke, *2001: A Space Odyssey* (London, 1968), a novel based on the screenplay by Clarke and Stanley Kubrick for the latter's film of the same name, which was hugely successful at the time – partly due to topicality (appearing in a period of fierce USA–USSR rivalry in interplanetary travel), but mainly due to slick special effects and loud music by more than one Strauss. The plot, which has no obvious connection with Homer, is partly a development of Clarke's short story 'The Sentinel' (1951). This story is the true subject of our reference since it depends upon mankind's being considered to have reached intellectual maturity in science when it succeeds in tampering with a 'sentinel' left on the Moon by representatives of a higher civilization capable of interstellar travel.

[4] Sociologists have used the term 'actors' categories', in a wider sense than that intended here, since the 1930s. The term became familiar to historians of science through its use by Shapin and Barnes in the late 1970s.

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figure of such acknowledged importance as Newton, and all our authors have in fact taken pains to point out the wider implications of their work.

The clearest example of the usefulness of such 'local' history is perhaps provided by Hunter. His discussion of Boyle's concern with religious questions of conscience is a reminder that religion bulked much larger in the lives of most of the people historians write about than it does in the lives of their counterparts today. Moreover, in providing a believable intellectual portrait of Boyle, Hunter shows up crucial weaknesses in earlier versions of some events given by historians for whom Boyle was essentially only one diagrammatic figure in a story not his own. A banal moral, which Hunter does not draw, is that this is, of course, a peril for every historian who works on a figure whose personal papers survive in quantity, particularly if they are largely unpublished.[5] What Hunter does do is to show that taking a new look at one particular area of Boyle's religious life can provide alternative explanations of matters relevant to Boyle's work as a natural philosopher.

Hunter's conclusions in regard to Boyle are notable for relying on 'external' factors in an argument directed in part against the neglect of them in work done by some historians who, at the time, appeared to regard themselves as more externalist than thou. A fair degree of externalism is, however, by now normal in history of science. Any debate between internalism and externalism appears to be dead – though one might, perhaps, by a suitable choice of battlements, arrange to encounter its ghost. There are no references to it among the historiographic remarks made by the contributors to this volume. Readers will see that we have chosen our words with care in referring to 'historiographic remarks'. Apart from Gabbey, whose subject is historiographic, and Cook, whose main conclusions are historiographic, none of our contributors is greatly concerned with historiographic issues, and even Cook's example tends to prove the rule in that he is directing attention to an imbalance in historians' choice of particular fields of scientific enquiry, rather than discussing a particular style of historiography. There seems to be general agreement that we are all cultural historians now – at least in regard to the period under consideration here. We are tempted to suggest that historians of the early modern period may have been brought to such a recognition by making a comparison between their work and that of the increasing number of their colleagues who are working on the history of science in much later periods, such as the nineteenth and twentieth centuries, for which much larger quantities of general information are available. In any case, the apparent community of outlook between our contributors has not been imposed either by the editors' choice of papers or by suggesting revisions. Similarly, these collected papers are notable for an absence of direct prescription and an absence of buzzwords. We are not in search of a label to apply to such a state.

This absence of policing of boundaries may be more apparent than real, but it is none the less accompanied by some of our contributors being willing to use their skills in areas which might be considered proper to other kinds of historian (other, that is,

[5] Hunter is currently working on Boyle's papers, and has published a guide to them. See Michael Hunter, *Letters and Papers of Robert Boyle: A Guide to the Manuscripts and Microfilm* (Bethseda, 1992).

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than a historian of science). For instance, Nutton's classical scholarship is turned to the task of examining the activities of his humanist predecessors, whose work he has, of course, been using in his own studies of their period and in his reading of classical texts; Hunter is contributing to, as well as making use of, the history of religious thought; Field, and Winkler and Van Helden, are effectively making contributions to the history of art as well as that of science; and, for instance, Dragoni's paper might well be seen as describing an episode of social history, though its relevance to the history of science is at once apparent if it is considered in relation to Casini's paper, in which several of the same actors appear. It seems to us that some, but not all, of this boundary crossing represents a commitment to using actors' categories. That buzzword is surely so old as to have become merely a technical term,[6] but behind it there stands the less well-observed but equally important notion of attending to the fact that disciplinary boundaries should also be seen in actors' terms. Westfall's paper can be read as, in a sense, a contribution to a better understanding of the position and nature of these disciplinary boundaries. Gabbey's paper gives a sharply focused view of the historiographic effects of working with an unfocused picture of them.

The problem of nomenclature in 'mechanics' to which Gabbey draws attention is of historians' own making – some of the historians in question being distinguished amateurs, such as Ernst Mach. Eamon's chapter, however, shows that such problems may sometimes be intrinsic: he makes it clear that Fioravanti's use of the word 'scientia', which one inevitably translates as 'science', is both loose and flexible. Neither of these forms of vagueness is likely to commend itself to the historian, except pragmatically, and in the short term. None the less, we all know that they are characteristic of the use of the same word in our own time, by the general public at least. Indeed, Fioravanti's slapdash, and polemical, usage of 'scientia' sometimes as meaning true understanding, and sometimes as indicating a collection of abstruse theory-encumbered prejudices, is both apparently 'modern' and apparently Paracelsian. Eamon's account of Fioravanti's work indicates, however, that his preoccupations were, if not conventional, at least closely bound up with issues that engaged the attention of his contemporaries, and that his general philosophy was not very close to that of Paracelsus. What Eamon calls Fioravanti's 'medical primitivism' involved relying on direct experience of nature. In making out his own case, however, Eamon may perhaps also be seen as suggesting, by his example, the usefulness of a form of historiographic 'primitivism', namely relying on a careful reading of primary sources.

Typified, perhaps, by Paolo Rossi's book about Francis Bacon (first published in Italian in 1957),[7] one tendency in modern historiography has been to show that many of the first generation of Heroes of the Scientific Revolution, figures such as Tycho (b. 1546), Galileo (b. 1564), Kepler (b. 1571) and Harvey (b.1578), had their feet firmly planted in a culture best described as Renaissance. For example, they all made creative use of newly established good texts or translations of ancient Greek

[6] See note 4 above.
[7] Paolo Rossi, *Francesco Bacone: Dalla magia alla scienza* (Bari, 1957); English translation *Francis Bacon: from Magic to Science* (London, 1968).

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scientific works. Copernicus (b. 1473) is conspicuous by his absence from this list because he clearly cannot be described otherwise than as a Renaissance humanist figure. Instead of describing figures of this first generation as 'transitional', it seems better to admit that historians themselves have supplied the Rubicon whose crossing they then proceed to celebrate. Looking at intellectual maps drawn up for other kinds of history suggests that we do not need to copy Ancient Roman tidy-mindedness – except perhaps for administrative purposes – and might find it useful to forget about drawing lines between a certainly ill-defined Renaissance, as Transalpine Gaul, and the Cisalpine Gaul of an at least somewhat ill-defined Scientific Revolution that is either the first phase of Modernity or the prelude to it.

An example of the usefulness of regarding the Scientific Revolution as a continuation of the Renaissance can be seen by comparing Eamon's chapter with that of Gabbey. Eamon is concerned with sixteenth-century Italy. Gabbey deals mainly with work done North of the Alps in the following century, but his chapter can be seen as importing into the study of what has been regarded as a characteristically seventeenth-century problem – perhaps reflecting the relationship of scholars and craftsmen – the intellectual tools which the work of the late Charles Schmitt has shown to be so useful in studying the Renaissance. Indeed, one of the authors to whose work Gabbey refers, namely Tycho Brahe, is in many ways a typically 'Renaissance' figure, as the late Victor Thoren's biography of him, aptly titled *The Lord of Uraniborg*, makes abundantly clear.[8] Furthermore, in allowing Kepler access to his books of astronomical observations, in a manner Kepler found infuriatingly restrictive, it would seem that Tycho was according him the privilege of making use of an astronomical version of a cabinet of natural curiosities put together in a spirit not unlike that which animated the seventeenth-century students of natural history discussed in Cook's paper.

Abolishing this metaphorical Rubicon is a suggestion from the editors. It will, however, be noted that the contributors seem inclined to eliminate Caesar. Their attention is, for the most part, turned away from the standard heroes or heroic episodes in the Scientific Revolution, and towards figures and events that tended to be regarded as minor or marginal by earlier historians. This attitude seems to be part of an established trend in modern historiography. An example is provided by the British Society for the History of Science Summer Meeting of 1987, a year much bedecked with tercentenary garlands for Newton's *Principia*. The meeting concerned itself with the life and work of Newton's contemporary, and sometime adversary, Robert Hooke. No bones were made about his being, compared with Newton, a relatively 'minor' figure, though there was the entirely justifiable claim that historians had paid him disproportionately little attention.[9] In the event, historians voted with their feet: the meeting was very well attended and the volume of selected papers edited by the

[8] V. E. Thoren, *The Lord of Uraniborg: A Biography of Tycho Brahe* (Cambridge, 1990). Thoren chaired one of the sessions at the Oxford conference.
[9] Michael Hunter and Simon Schaffer (eds.), *Robert Hooke: New Studies* (Woodbridge, 1989), Introduction.

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organizers has been equally well received.[10] Hooke is, of course, somewhat exceptional among 'supporting actors' in being relatively well documented – for instance by the survival of his private diary for certain years, which tells us a great deal about his day-to-day personal contacts. As Rupert Hall points out in his Afterword to this volume, on the whole 'major' figures tend to have left us with more information to go on. Presumably today's trend towards studying 'minor' figures and 'minor' episodes goes with the habit of setting them in their wider cultural context, since understanding this context can compensate for the relative paucity of direct evidence. In a way, such studies show the context becoming the content. However, it must be admitted that they also ignore the principle of looking for the lost coin under the lamp post because that is the only place one has a hope of finding it.

One previously marginalized area which becomes more central in this volume is that of work done in Italy. In view of the industrial scale of research on Galileo, it may seem unreasonable to claim that Italian natural philosophy has been neglected, but a closer inspection of the literature shows that, apart from much excellent work on Renaissance Aristotelianism, historical investigation has in fact been remarkably closely concentrated on Galileo and his immediate contacts. Relatively little attention has been paid to subjects in which he did not make what Whig historians would recognize as revolutionary advances. Moreover, possibly due to long-term influence by historians engaged in covert Protestant polemic, such as David Brewster, it seems too readily to have been assumed that the condemnation of Galileo by the Catholic Church led to an inexorable decay of the scientific elements of Italian civilization, whose later story could thus present little of interest. (Thus the rich field of nineteenth-century Italian science has been largely neglected.) Casini's account of the reception of Newton's optical work in Italy is a distinguished contribution to proving such a view mistaken. He uncovers a lively world of intellectual activity and academic and social careerism in which the background threat of the Inquisition, though real, could nevertheless be avoided if one took sufficient care.[11] Intellectual, religious and political threat are seen to go together. Thus the situation Casini describes integrates history of science into a wider history. In this case, good internal history of science and good external history of science have simply become the same thing. Perhaps a hidden assumption of their necessarily being antithetical has helped to perpetuate the Brewsterian neglect of events in Italy.

Protestant polemic having faded out of historians' overt agenda, Brewster's portrayal of Galileo as a Martyr to Catholicism (1841)[12] has become transmuted and generalized into the perception of a possibly antagonistic interaction between Religion and Science. The case of the reception of Darwin's theory of evolution has apparently

[10] *Ibid*. Reviewed by M. B. Hall in *Arch. Int. Hist. Sci*., 1990, **40**: 400–1, which endorses the editors' opinions about the earlier neglect of Hooke and his work and points out that much still remains to be done.

[11] The place of the Inquisition in this world is rather like an attenuated version of that of the Austrian system of political repression in the world of Stendhal's novel *La Chartreuse de Parme* (1839) – which is based on historical characters who lived in Italy in the sixteenth century, so the similarity is probably not entirely fortuitous.

[12] See J. R. R. Christie, 'Sir David Brewster as an historian of science', in A. D. Morrison-Low and J. R. R. Christie (eds.), '*Martyr of Science': Sir David Brewster 1781–1868* (Edinburgh, 1984), 53–6.

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tended to harden today's scientists', and sometimes also today's historians', belief that the possibility of antagonism is important. This would seem to be the most natural reading of John Brooke's recent *Science and Religion* (1992). There appears, however, to be a tacit assumption that, while Science is a continually changing system – indeed changing so much that the use of the word 'science' is dubious for its earlier forms – Religion, or rather religious belief, has no history. Given the Darwinian model and the multifarious nature of religion in nineteenth-century Britain, the thought of Michael Faraday would seem to provide an interesting test case. His absence from Brooke's book is apparently a consequence of the author's decision to concentrate on the relation between Christianity and the geological and biological sciences in this period.[13] With the thought of Johannes Kepler, whose not quite orthodox brand of Lutheran Protestantism is seamlessly continuous with his natural philosophy, as Hübner showed in his *Die Theologie Johannes Keplers zwischen Orthodoxie und Naturwissenschaft* (1975), the Darwinian model breaks down equally spectacularly. One might perhaps expect this model to be unimportant for historians of the Scientific Revolution, but that is to accept too simple a rational reconstruction. Historians of science on the whole appear to have adopted a modified Brewsterianism which allows them to see Galileo as by far the most important natural philosopher of his time. Kepler, a Protestant, whose excommunication for unorthodox beliefs concerning the relation of spirit and matter in the doctrine of the Eucharist is presumably considered irrelevant, is seen as a relatively unimportant figure, merely a *mathematicus* (which is to ignore the fact that, like Galileo, Kepler also claimed to be a natural philosopher).[14] Their distinguished contemporary William Harvey, into whose concerns matters of religion are apparently deemed to enter hardly at all, provides an even weaker example of Religion *versus* Science and gets even shorter shrift. This, at least, is the picture of the historiography of the Scientific Revolution that one obtains if one looks at the balance in the literature as a whole. It is faithfully reflected in Brooke's *Science and Religion*, and is also visible in the volume of essays edited by Lindberg and Westman, entitled *Reappraisals of the Scientific Revolution* (1990). The crude measure provided by the number of index entries in the volume is confirmed by reference to the main text. Ernan McMullin, writing on 'Conceptions of science in the Scientific Revolution',[15] devotes three and a half pages to Kepler,[16] followed by eight to Galileo, and the section on Galileo begins

> In this and the next section we come finally to the two scientists whose names most easily come to mind when the Scientific Revolution is men-

[13] For Faraday's religion, see G. N. Cantor, *Michael Faraday: Sandemanian and Scientist. A Study of Science and Religion in the Nineteenth Century* (London, 1991).

[14] Field is grateful to Owen Hannaway for pointing out, in a private conversation in 1989, that Kepler's quasi-chemical problem with the Eucharist was closely similar to his problems of relating force and matter in his physics.

[15] Ernan McMullin, 'Conceptions of science in the Scientific Revolution' in Lindberg and Westman, *op. cit.* (note 1), 27–92.

[16] These pages are about Kepler's *A Defence of Tycho against Ursus*, an unfinished work which remained unpublished in the author's lifetime, but was printed in the original Latin and in English translation in N. Jardine, *The Birth of History and Philosophy of Science: Kepler's A Defence of Tycho against Ursus, with essays on its provenance and significance* (Cambridge, 1984), to which numerous references are given. No attempt is made to use Kepler's scientific works as evidence, as is done for Galileo.

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> tioned. Galileo began a mathematization of Nature that Newton carried to its triumphal conclusion.[17]

There is no mention of Harvey. He is, however, referred to in Cook's 'The new philosophy and medicine in seventeenth-century England'[18] a section of which considers the general neglect of history of medicine.[19] We are, of course, not suggesting that most historical work is actually Brewsterian, but the fact remains that Brewster and his ilk seem to have played a large part in determining historians' choice of problems.

Nor is the balance greatly righted by the simultaneous influence of a more recent historiography which has emphasized the revolutionary effect of Platonism (usually understood as involving increased use of mathematics, but sometimes as an injection of Neoplatonic magical reasoning) against the entrenched Aristotelianism of conventional natural philosophers. This style again tells against Harvey and, because it was at the time more usual than it is now to take Galileo's word for how un-Aristotelian his opinions were, again emphasizes Galileo. Kepler, whose personal letters happen to survive in large quantity, frequently emerges as having a personality problem, being a Platonic cosmologist with an Aristotelian physics, and thus, in appropriately humanist style, is sometimes described as Janus-faced. We do not wish to suggest that any serious historian working today would ignore the important work that the late Walter Pagel and others have done on Harvey's philosophical beliefs (and indeed the connections between his work and religious beliefs),[20] or would fail to take account of the valuable aid to understanding provided by recent studies that show the continuing vigour of Aristotelian work in natural philosophy.[21] Moreover, as Martins' contribution to this volume makes clear, Aristotelian ideas continued to play an important part in determining what constituted an acceptable form of scientific reasoning, as is seen in the philosophical obstacles Huygens encountered in reading Newton's *Principia*. The continuing influence of Aristotelianism, which is also illustrated in Dragoni's essay, is well recognized in the work of most historians today. None the less, analysis in terms of Platonism does seem to have played a part in reinforcing Brewsterian

[17] McMullin, *op. cit.* (note 15), 62.
[18] Harold J. Cook, 'The new philosophy and medicine in seventeenth-century England', in Lindberg and Westman, *op. cit.* (note1), 397–436.
[19] *Ibid.*, 401–5.
[20] W. Pagel, 'Religious motives in the medical history of the seventeenth century', *Bull. Inst. Hist. Med.*, 1935, 3: 97–128, 213–31, 265–312; reprinted in W. Pagel, *Religion and Neoplatonism in Renaissance Medicine*, edited by M. Winder (London, 1985). Also Pagel's 'The reaction to Aristotle in seventeenth-century biological thought: Campanella, Van Helmont, Glanvill, Charleton, Harvey, Glisson, Descartes', in E. A. Underwood (ed.), *Science, Medicine and History: Essays on the Evolution of Scientific Thought and Medical Practice written in Honour of Charles Singer*, (2 vols., Oxford, 1953), 1: 489–509; and Pagel, 'Harvey and Glisson on irritability with a note on Van Helmont', *Bull. Hist. Med.*, 1967, 47: 497–514; both of these papers are reprinted in Pagel, *From Paracelsus to Van Helmont: Studies in Renaissance Medicine and Science*, edited by M. Winder (London, 1986). See also, C. Hill, 'William Harvey and the idea of monarchy', in C. Webster (ed.), *The Intellectual Revolution of the Seventeenth Century* (London, 1974), 160–81, esp. pp. 169–73 (first published in *Past Present* in 1964), but see ensuing discussion G. Whitteridge, 'William Harvey: a Royalist and no Parliamentarian', *ibid.*, 182–8, and C. Hill, 'William Harvey (no Parliamentarian, no heretic) and the idea of monarchy', *ibid.*, 189–96.
[21] See, for example, the accounts of Jesuit work on electricity and magnetism in J. Heilbron, *Electricity in the Seventeenth and Eighteenth Centuries: A Study in Early Modern Physics* (Berkeley, 1979), and Heilbron, *Elements of Early Modern Physics* (Berkeley, 1982).

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predilections in historians' choice of subjects. Curiously enough, further reinforcement has recently come from the Vatican. In connection with an Einstein centenary, in 1979, Pope John-Paul II instituted a series of publications to deal with 'the Galileo case'.[22] Since Galileo's condemnation appears to have been connected with his Copernicanism,[23] this papal intervention tends to support the historiographic tendency that may also partly derive from the importance given to mathematical sciences in the writings of scholars interested in the influence of Platonism or some form of Neoplatonism, namely the tendency to see astronomy as particularly important. What has come to be called the 'Copernican Revolution'[24] is thus sometimes presented as if it provided a paradigm for (or picture in little of) the processes at work in the Scientific Revolution as a whole.[25] Historians of other subjects in this period are left to cope as best they can with what, adapting Steven Jay Gould's parody of Freud, one might call 'astrophysics envy'.[26] Such envy is not a problem for today's scientists, since astrophysics is now heavily encumbered with proliferating subatomic particles, thus putting it in the unenviable state summed up by Fermi's alleged remark 'If I could remember all those names I'd be a botanist.'[27]

That 'botany envy' appears to be unknown in our own time no doubt encourages historians – and perhaps particularly those whose background lies in science – to see natural history as 'backward' in the seventeenth century. In any case, it does not fit very well into the larger theoretical frameworks for describing the development of natural philosophy designed by Brewsterians or Platonizers. However, the striking changes in some parts, dependencies or appendages of natural history, describable as 'the life sciences', changes which may very reasonably be regarded as 'revolutionary', have until relatively recently been seen as coming within the remit of the interpretive system epitomized in the title of Dijksterhuis's *The Mechanization of the World Picture* (1958).[28] Unfortunately for the coherence of such an interpretive system, the group of seventeenth-century theories of matter that are still usually designated as 'the mechanical philosophy' have increasingly been shown to include crucial elements that are incompatible with the standard interpretation of 'mechanical' as meaning explanation purely in terms of matter and motion.[29] It seems likely soon to become an orthodox opinion to hold that the only true mechanist was probably Descartes, with Aristotle as the next-best candidate. In particular, it has been clear for some time that any mechanical philosophy encountered problems with explaining attraction –

[22] The series is called *Studi Galileiani, Research Studies Promoted by the Study Group Constituted by John-Paul II*, the publisher is Vatican Observatory Publications (Vatican City). The first volume appeared in 1984.
[23] Vigorous advocacy for an alternative view is to be found in P. Redondi, *Galileo eretico*, (Turin, 1983); English translation, *Galileo Heretic* (Princeton, 1987).
[24] From the title of T. S. Kuhn, *The Copernican Revolution* (Cambridge MA, 1957).
[25] T. S. Kuhn, *The Structure of Scientific Revolutions* (Chicago, 1962).
[26] Gould contrasts 'historical sciences' (such as geology and palaeontology) with experimental and mathematical sciences (such as physics). The former sciences are regularly accorded lower intellectual status. Their practitioners are thus diagnosed as subject to 'physics envy'. S. J. Gould, *The Mismeasurement of Man* (New York, 1981).
[27] Enrico Fermi (attrib.). Fermi had a reputation for wit.
[28] First edition, in Dutch, Amsterdam, 1950, German translation 1956, English 1961.
[29] J. Henry, 'Occult qualities and the experimental philosophy in pre-Newtonian matter theory', *Hist. Sci.*, 1986, **24**: 335–81; and Henry, 'Robert Hooke, the incongruous mechanist', in Hunter and Schaffer *op. cit.* (note 9), 149–80.

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electric, magnetic or chemical – and the concomitant notion of 'force' as action at a distance. It is accordingly significant that in his contribution to this volume Gad Freudenthal is able to show that one widely accepted 'mechanical' explanation for attraction appears to be derived from a Stoic notion incorporated into the Aristotelian theory of matter in order to deal with the related problem of cohesion. Freudenthal's argument thus tends – though this is clearly not its main purpose – to lend further support to the view that much of the mechanistic explanation of the seventeenth century was in fact derived from an Aristotelian tradition. This fits in well with the modern picture of Harvey as deeply indebted to Aristotle, and thus a 'mechanist' in rather the same way, for instance in believing that form must follow function. Since Aristotle's ablest pupil, Theophrastus, is now chiefly remembered for his (thoroughly Aristotelian) work on systematizing the study of plants, one may perhaps hope that botany, and natural history as a whole, will eventually be drawn into this larger picture of the continuing influence of Aristotelian styles of thought. It may be that what is required for the revival of historians' interest in natural history is a better integration of history of medicine into the history of science proper. The contributions of both Cook and Westfall could be read as providing arguments for such an integration, since each demonstrates that it would be in accord with the way the subjects were perceived at the time concerned.[30]

Support for the same view can also be deduced from Nutton's analysis of the printing history of Greek scientific texts. Though there is a slight time lag – mathematics, in which we include the mathematical sciences, got off to a slower start than medicine – the story is essentially the same for both. Greek texts seem to have found a relatively restricted readership and were followed by Latin translations and commentaries, which proved to be more popular. This aspect of the history of mathematics is largely ignored in Rose's *The Italian Renaissance of Mathematics* (1975), which is concerned with humanists and translators rather than their readers. Moreover, it has been almost completely neglected by most historians of mathematics. Possibly for reasons of technical competence – since it is, to put it bluntly, rather difficult to get to grips with the mathematics underlying the presentational rhetoric in many Renaissance mathematical texts – the history of mathematics has tended to be written by mathematicians for their peers, with emphasis on the mathematical content. The style of such work tends to look rather old-fashioned to most historians of science. However, as can be seen in the Platonizing-mathematization model for the Scientific Revolution, the history of mathematics undoubtedly has substantial connections with developments in natural philosophy as well as in the mathematical sciences. In this volume, Westfall's contribution makes clear that there were many 'scientists' whose everyday activities engaged or depended on their mathematical skills. Field's contribution discusses how mathematical skill can be seen to be embedded in the craft of the painter, and Willmoth's contribution examines the institutionalization of mathematical skills in the Ordnance Office. It is beyond the

[30] See also Cook, *op. cit.* (note 18), 401–5.

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