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NATURAL PHILOSOPHY OR SCIENCE IN PREMODERN EPISTEMIC REGIMES? THE CASE OF THE ASTROLOGY OF ALBERT THE GREAT AND GALILEO GALILEI

Abstract: *Scholarly attempts to analyze the history of science sometime suffer from an imprecise use of terms. In order to understand accurately how science has developed and from where it draws its roots, researchers should be careful to recognize that epistemic regimes change over time and acceptable forms of knowledge production are contingent upon the hegemonic discourse informing the epistemic regime of any given period. In order to understand the importance of this point, I apply the techniques of historical epistemology to an analysis of the place of the study of astrology in the medieval and early modern periods alongside a discussion of the "language games" of these period as well as the role of the "archeology of knowledge" in uncovering meaning in our study of the past. In sum, I argue that the term "science" should be used only with the greatest care and the utmost hesitancy when studying approaches to knowledge formation prior to the seventeenth century.*

Keywords: *history of science; astrology; Albert the Great; Galileo; epistemic regime*

Filosofie přírody, nebo věda v předmoderních epistemických režimech? Případ astrologie Alberta Velikého a Galilea Galilei

Abstrakt: *Badatelské snahy analyzovat dějiny vědy někdy trpí nepřesným používáním termínů. Pokud mají přesně porozumět tomu, jak se věda vyvíjí a kde se nacházejí její kořeny, výzkumníci by měli s pečlivostí rozpoznat, že epistemické režimy se mění v průběhu času a akceptovatelné formy produkce vědění se odvíjejí od hegemonického diskurzu, jenž zásadně formuje epistemický režim každé dané doby. Pro pochopení důležitosti této pointy používám techniky historické epistemologie k analýze místa astrologického bádání v obdobích středověku a raného novověku, spolu s diskuzí o "jazykových hrách" těchto období a také o roli "archeologie vědění" v odkrývání významu v našem zkoumání minulosti. V souhrnu tvrdím, že termín "věda" by měl být používán pouze s nejvyšší opatrností a se značným váháním, pokud má sloužit pro zkoumání přístupů k utváření vědění před 17. stoletím.*

Klíčová slova: *dějiny vědy; astrologie; Albert Veliký; Galileo; epistemický režim*

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Science is a term frequently employed with little regard for historical context. Modern researchers such as David Pingree have sought to describe and defend the work of Babylonian astrologers as "science"[1] while others such as David Lindberg have pointed to work in the same discipline as one example among many of the high level of development in the sciences to be found in medieval Europe.[2] However, the use of the terms "science" and "scientific" in these ways is only possible if one ignores the very different regimes of epistemic discourse that prevailed in these premodern societies. Furthermore, application of the term "science" to the work of scholars such as the thirteenth-century theologian who has been saint of scientists since 1931, Albert the Great (d. 1280), or his near contemporary Robert Grosseteste (d. 1260), imposes a series of expectations and perception-altering filters that only increases the distance between us and these historical actors. Instead, there are sound reasons for a return to the use of the term natural philosophy that, for all its imprecision, reveals rather than imposes meaning on the past.

A discussion of terminology might seem pedantic, but nothing could be further from the truth in regards to the current issue: If we wish to understand accurately the history of science, it is useful to begin by reframing the terms of our study of the past. Attempting to identify premodern "scientists" and "sciences" is epistemologically unsound and attempts to do so are derived from unexamined assumptions based on limited consideration of the language game of the modern scientific epistemic regime within which researchers are necessarily embedded. The various elements in this argument will be examined below, but before we move on it would serve us well to start with the recognition that as the philosophers of science Boris Castel and Sergio Sismundo have said, "The modern world, and perhaps what it means to be modern, is thoroughly entwined with science,"[3] a situation that has led to a virtual redefinition of the terms "rational" and "scientific"[4] as near

I would like to thank Dr. Kevin Guilfoy for inspiring me to think deeply about this subject.

[1] David PINGREE, "Astrology." In: YOUNG, M. J. L. – LATHAM, J. D. – SERJEANT, R. B. (eds.), *Religion, Learning, and Science in the 'Abbasid Period*. Cambridge: Cambridge University Press 1990, p. 290–299.
[2] David C. LINDBERG, *Science in the Middle Ages*. 2nd printing. Chicago: University of Chicago Press 1980.
[3] Boris CASTEL – Sergio SISMUNDO, *The Art of Science*. Toronto: UTP Higher Education 2003, p. 9.
[4] Alvin I. GOLDMAN offers a vigorous defense of such an equation in his work, *Knowledge in a Social World*, Oxford: Oxford University Press 1999, p. 248–254, *passim*.

synonyms in our modern world. However, we should not assume that a modernist rationality is the only viable form of that discourse. Understanding the past requires a more serious application of the archeology of knowledge than is indicated by the ahistorical application of terms created to explain modern exercises in the formation of knowledge, and a failure to recognize the problems inherent with such an approach creates a serious potential for confusion about what historical actors were actually doing and where their intellectual pursuits fit within their own cultures, as well as in any history of the development of knowledge. In order to clarify why this is important, I will compare medieval European astrology and astronomy with similar pursuits undertaken by early-modern Europeans such as Galileo Galilei as case studies to demonstrate the heuristic value of historical epistemology.

But first, in order to establish the theoretical framework for my work, I should briefly explain what I mean when I use the term epistemic regime, before going on to a discussion of the role of language games and the archeology of knowledge as related to my current study. Taking up the concept of the epistemic regime first, its usefulness to my work lies in the fact that it refocuses our understanding of idea and knowledge formation away from wholly voluntaristic models while indicating how selectivity and action within the realms of intellectual action occur within a web of internal and external regulative frameworks.[5] This regulation does not occur completely within the mind of the individual, though as I will argue below the unspoken and unexamined set of assumptions informing the questions one asks and how one goes about answering those questions are important factors. Connected to those sets of issues, though, is the interrelated social, political, economic, and educational dimensions constituted by "sets of implicit or explicit principles, norms, rules, and decision making procedures around which actors' expectations converge,"[6] as with any other regime. Therefore, within any given epistemic regime, knowledge production, as well as what constitutes knowledge and proof, is predicated upon a host of historically and socially-contingent factors.

[5] Michel FOUCAULT, *The Archaeology of Knowledge*. A. M. Sheridan Smith (trans.). New York: Pantheon Books 1972, p. 69–70; Aant ELZINGA, "Science as the Continuation of Politics by Other Means." In: BRANTE, T. – FULLER, S. – LYNCH, W. (eds.), *Controversial Science: From Content to Contention*. Albany: State University of New York 1993, p. 127–152. I would hasten to add that neither am I attempting to deny *wholly* the role of voluntaristic exercises on the part of individual scientists. The point I wish to make is that such willed actions never occur completely independent of external influences and internal mental structures.

[6] Stephen KRASNER, *International Regimes*. Ithaca: Cornell University Press 1983, p. 2.

However, the ways in which one communicates knowledge, as well as builds it in a collaborative social venture, is dependent upon the uses of language and words. As Ludwig Wittgenstein argued, the meaning of a word is dependent on its use – linguistic statements have no independent ontological status.[7] Thus, in order to understand any statement, be it a word, a sentence, or a larger construct, the interplay between language and language user must be considered. The use of language is not random, as the language, the actions of its users, and the users themselves all interact within the framework of a language game and its rules.[8] ″Given these broadly-defined rules, within any given cultural context there are countless ways in which words can be manipulated to create sentences and almost as many different meanings for individual words. Perhaps more important to the topic here under consideration, language games are dynamic and continually changing, with new ones coming into being and old ones passing away continually.[9] Even a surface consideration of the way the Internet has changed the use of language will support this argument, with old words such as "web" taking on entirely new meanings and new terms such as "download" being regularly generated. In contrast terms with ages reckoned in decades are already passing into obscurity: few modern teenagers would readily associate the term "cassette" with music, if they even knew what the word meant.

Therefore, in order to understand what any word means, an individual must always learn its role in the language game, which requires historical and cultural contextualization. Its use will always be rule governed and terms functioning outside the boundaries of these rules have no meaning. However, as stated previously, the rules in question are not immutable, but instead are historically and socially contingent. Perhaps even more importantly for our current study, analysis of the discontinuities involved with language use, or dispersion as Michel Foucault would term it, is itself part of the process of understanding any given statement.[10] This analysis must take into account that the statement – or in this case word – involves not only a referent but also an associated field through which statements and words can interact in discursive formations.[11] Such formations carry important connotative as well as denotative meaning for all terms involved in their

[7] Ludwig WITTGENSTEIN, *Philosophical Investigations*, G. E. M. Anscombe (trans.). New York: Macmillan 1953, section 11.
[8] *Ibid*., section 7.
[9] *Ibid*., section 23.
[10] FOUCAULT, p. 37.
[11] *Ibid*., p. 86–99.

construction and must be understood as elements of the "archive" of a given culture, meaning not only the terms themselves but also the interrelated historically-contingent elements of which any given term makes up a part. In other words, the use of a term such as "science" necessarily involves an invocation of the set of ideas and practices that gave it birth, denoting its place within a specific language game. When employed by a language user it is almost impossible for it not to condition the way he or she considers the subject of analysis, nor can such a use help but influence the assessment of a language hearer, or reader as the case may be. What is conveyed, then, is not a meaning associated with a single term, but instead a range of meanings associated with a discursive formation conditioned by an epistemic regime of modern scientism.

Therefore, when a modern researcher uses a term that would have been unknown to the historical actors to whom it is applied, such as "scientist" or even "science," the choice for so doing is conditioned by the hegemonic discourse within which the language user functions making such a use far from a value-neutral descriptor, but in fact a deeply value-laden judgment about what is being observed.[12] The word "science" is chosen rather than some other term because of the immense cultural capital that it commands within a modernist epistemic regime and the habitus[13] – the unexamined and unacknowledged assumptions of the researcher imparted largely by the hegemonic discourse within which he or she lives – that privileges scientific modes of rationality over all others. Thus, when a modern intellectual applies the term "science" to an intellectual construct existing prior to the invention of science – and science should be recognized as a set of techniques and ways of examining the world that was invented in the early modern era, as I will discuss below – what he or she is actually doing is making a value judgment about what is and is not rational about the actions of historical actors. In

[12] For a discussion of the way hegemonic discourses are constructed and self perpetuate, as well as affect the perceptions of those embedded within the discourse, see Antonio GRAMSCI, *Prison Notebooks*. Volume III. Joseph A. Buttgieg (trans.). New York: Columbia University Press 2007; James A. MARTIN, "Between Ethics and Politics: Gramsci's Theory of Intellectuals." In: MARTIN, J. (ed.), *Antonio Gramsci: Critical Assessments of Leading Political Philosophers*. London: Routledge 2002, p. 124–144.

[13] For the concepts of various forms of non-material capital as well as habitus, see: Pierre BOURDIEU, "The Peculiar History of Scientific Reason." *Sociological Forum*, vol. 6 1991, no. 1, p. 3–26; Pierre BOURDIEU, "Participant Objectivation." *The Journal of the Royal Anthropological Institute*, vol. 9, 2003, no. 2, p. 281–294; Joseph MARGOLIS, "Habitus and the Logic of Practice." In: SHUSTERMAN, R. (ed.), *Bourdieu: A Critical Reader*, Oxford: Blackwell 1999, p. 64–83.

turn, even an astute reader is prompted to classify intellectual exercises of the past as "scientific" or "superstitious," "rational" or "irrational," based upon how closely those activities appear to mirror the activities of a modern scientist. The result is a deep epistemic confusion about activities of the past as can be seen – to provide only one example – in the way different historians speak about the study and use of astrology by premodern Europeans. One of the most important historians of science of the twentieth century, Alistair Crombie, when writing about the medieval and early modern periods refers to astrology habitually as a "superstition"[14] while others, such as Alexsander Birkenmajer, studying the same period have highlighted astrology as an important science.[15] Obviously both estimations cannot be correct, and in fact neither are accurate. Instead, such statements are the results of a failure to apply the techniques of historical epistemology, which itself requires historical and social contextualization of both the methods of knowledge construction and the terms used therein in order to make meaningful sense of the terms constituting the statement.

This failure is understandable, though, given the imprecise way in which science is both used as a term and understood more broadly. Rigorous scholars such as Kenneth Robinson apply the term to activities such as those of Chinese traditional medicine[16] that are far more tradition than theory laden while in popular culture it is a word that is habitually used in place of "method" or "procedure," such as the "science of getting rich" or the "science of cooking." To a degree, this is reflective of a somewhat muddled historical use of the term, as revealed by the *Oxford English Dictionary*. Having been derived from the Latin word, *scientia*, which means "certain knowledge," Richard Hampole seems to have introduced the word "sciens" to the English language in his 1340 commentary on the Psalms.[17] Judging by the varied ways in which it was used over the next four centuries, most participants within the various language games that went along with the evolving epistemic regimes that developed and gave way to newer discourses during this period thought of the word as the equivalent of "knowledge" or "academic discipline," but by the close of the eighteenth century we see the term be-

[14] A. C. CROMBIE, *Augustine to Galileo: The History of Science A.D. 400–1650*. 3rd edition. Mineola: Dover Publications 1995, p. 36.
[15] Alexsander BIRKEMAJER, *Etudes d'Histoires des Sciences en Pologne*. Claire Brendel (trans.). Warsaw: Zaklad Narodwy im. Ossolinskich 1972, p. 276–308.
[16] Joseph NEEDHAM, *Science and Civilisation in China*. Volume VII. Robinson, K. G. (ed.). Cambridge: Cambridge University Press 2004, p. 235.
[17] *The Oxford English Dictionary*. 2nd ed. 1989. *OED Online,* s.v. "science."

ing applied in a much more specific way by some authors. Richard Kirwan in his 1796 *Elements of Mineralogy* stated that "Previous to the year 1780, mineralogy, though tolerably understood by many as an art, could scarce be deemed a Science." What seems to have supplied the distinction between art and science for Kirwan was the methodology of testing coupled with an understanding of proof that privileges empirical demonstrations, alongside a form of presentation designed to allow other researchers readily to follow the chain of thought and experimentation leading to any given scientific development, all of which becomes clear in Kirwan's correspondence with Henry Cavendish (d. 1810).[18]

I do not mean to argue that the practices and procedures of science were a creation of the eighteenth century – something I will address below – nor do I wish to suggest that words should never be used to signify practices or things that existed prior to the development of a term or the settling of its definition. Far from it, for one of Foucault's essential insights is that words and the discursive formations of which they form a part never develop a settled meaning, but instead change in definition as the hegemonic discourse that forms larger webs of meaning[19] for the society shifts. However, it is important that before applying any term in an ahistorical manner we should first be very clear about what that term actually means as well as what we mean by it when applying it to the past. Otherwise, the resulting distortion will filter and warp our view of the past in wholly unacceptable ways.

So how are we to understand the term science? Attempts to understand what science is or is not have generated a vast literature in recent years and it is not my intention to wade into that debate. Nor do I wish to enter into the discussion about whether or not science functions as scientists themselves frequently assume it to work, as the answer to that question is largely irrelevant to my argument. Instead, what I hold to be important to my current study are the broad outlines of what people conceptualize when they hear the term science. While this is certainly to a greater or lesser degree dependent on the individual under consideration, it is possible to uncover what is generally signified by the term through careful consideration, which I will undertake here before moving on to an analysis of why, precisely, it

[18] Christa JUNGNICKEL – Russell MCCORMACH, *Cavendish, The Experimental Life*. 2nd edition. Bucknell University Press 2001, p. 366–370.
[19] My thinking on "webs of meaning" has been influenced by W. V. QUINE, particularly his *From Stimulus to Science*. Cambridge, MA: Harvard University Press 2005.

is epistemologically unsound to employ the term in the study of history as loosely as is all too commonly done.

Despite Alex Hill's confident statement at the turn of the twentieth century that "everyone knows what the term science means, and appreciates its value as an amplification of the term knowledge,"[20] the situation is not quite that simple. More concrete attempts to distill the essence of what is meant by science have ranged from those that are intentionally broad ranging to those that have made efforts to be as concretely particularistic as possible. For example, the Hungarian-born chemist and philosopher of science, Michael Polanyi (d. 1976), chose to focus on the role of imagination and intuition in the work of the scientist, while emphatically arguing for equivalencies in other forms of research.[21] However, Polanyi recognized that science is a rule-governed exercise, even if the rules in question are not the same for every science and are not always easy to definitively describe. On the other hand, in an effort to develop a universal standard enabling a clear separation between science and pseudoscience, Karl Popper (d. 1994) developed the rule that "the criterion of the scientific status of a theory is its falsifiability, or refutability, or testability."[22] In other words, a scientific hypothesis must make "risky predictions" that may be tested in ways that allow for either confirmation or refutation and such testing rests upon the gathering and evaluation of data that is understood in strictly empirical terms. All of this is very well known, but the implications of Popper's model, which has garnered wide-spread (though by no means universal) support among both scientists and philosophers of science, are not always fully acknowledged: science is by necessity a form of social knowledge intertwined with and dependent upon mathematics.

Such a statement should come as no great surprise to my readers. As just one example, Herbert Simon has discussed the role of mathematics in science both as a language of proof, guaranteeing rigor that will necessarily lead to correct conclusions, as well as a language of discovery generating solutions that may be "checked for correctness."[23] However, the implication of the importance of mathematics to the way we understand what constitutes science is rarely articulated or acknowledged; science functions

[20] Alex HILL, *Some Problems of the Day in Natural Science: An Introduction*. London: J. M. Dent 1900, p. 1.
[21] Michael POLANYI, *Meaning.* Prosch, H. (ed.) Chicago: The University of Chicago Press 1975, chapter 3.
[22] Karl POPPER, *Conjectures and Refutations*. London: Routledge and Keagan Paul 1963, p. 34.
[23] Herbert A. SIMON, *Models of My Life*. New York: Basic Books 1991, p. 106–107.

as a mathematically logical exercise in which condition *W* plus theory *X* multiplied by experiment *Y* leads to proof *Z* in a necessary and mathematical fashion. The epistemological challenges to such a viewpoint need not detain us here; what is more important to note is that the very model held in the minds of those working within the modernist language game of what it is to *do* science is drawn directly from mathematics, presenting scientific exercises as a form of computational exercise allowing for linear truth discovery. This fact explains why physics – as the most mathematical of all the sciences – is typically held up as the paradigm for and most prestigious of all the sciences.[24] This is directly coupled with the model of science as social knowledge in that a scientist's work must be presented in a fashion that reveals his or her assumptions, actions taken to test them, data, and conclusions or else what is occurring is not seen as science by the scientific community or in the popular imagination.[25] Certainly this understanding of science presents important epistemological challenges, such as those provided not only by the distorting effects of scientists' own biases, fears, and desires but also the needs, available funding, and other concerns found in any given society, as studied by Helen Longino among others.[26] What is most important to understand in regards to my current argument, however, is that both among working scientists and scholars of science, science is conceived of as functioning through the production of testable knowledge claims, through a process wedded to mathematics and carried out in a social environment of some sort. In other words, when a modern researcher uses the term "science," he or she is deploying a contextually-specific term with a host of value attributions and assumptions embedded within that term. It is a use that is central to a modern epistemic regime that sees proof in empiricist terms, which is incompatible with those regimes structured by discourses that view and evaluate the world following different models of knowledge construction.

The connections between science and empiricism have attracted considerable study, including fruitful explorations of the links between the two

[24] For a deconstruction of this valuation of physics, see Sarah Lucia HOAGLAND – Marilyn FRYE, "Feminist Philosophy." In: CANFIELD, J. V. (ed.), *Philosophy of Meaning, Knowledge and Value in the Twentieth Century*. London: Routledge 1997, p. 209–232, 216.

[25] Sergio SISMONDO discusses this point at length in *Science without Myth: on Constructions, Reality, and Social Knowledge*. Albany: State University of New York Press 1996, chapters 3 and 4.

[26] Helen E. LONGINO, *Science as Social Knowledge*. Princeton: Princeton University Press 1990, especially chapters 8 through 10.

and the relationship with not only the period commonly called the Scientific Revolution but also the Enlightenment.[27] Furthermore, the way in which practices and thought patterns that both inform and are informed by science influence unrelated activities, from law to democracy, have been examined by scholars such as Alvin I. Goldman. Whether in the courtroom or in the voting booth decision making in the modern world is at least superficially influenced by concepts of proof and standards of argumentation influenced by modern science.[28] However superficial that influence might be, scientism – the belief that the scientific method is the most reliable method of getting at a truth grounded in empirically-knowable reality – is a trend that runs throughout modern thought,[29] proving the hegemonic power of this epistemic regime. However, as mentioned earlier these concepts are part of a specifically modern discourse. In order to understand how far the viewpoints of this discourse diverge from those of the past, we should turn to examples that will demonstrate the confusion that results when one uncritically applies a term such as "science" that is so deeply interwoven with the discursive formations that inform modernity, turning first to the high Middle Ages.

That the Middle Ages in Europe were an "age of faith" was an axiom with a long pedigree well before Edward Gibbon made it central to his eighteenth-century explanation for the decline and "fall" of the Roman Empire. Much more recently, Edward Grant has taken the idea far more seriously in his consideration of how this fact influenced the pursuit of knowledge for medieval intellectuals in his study *God and Reason in the Middle Ages*.[30] Arguing forcefully that the Middle Ages, or at least the high and late Middle Ages, were as much an age of reason as of faith, Grant challenges the notion that the two ideas are necessarily in conflict, and in the process outlines a medieval epistemic regime (though without ever using the term) that functioned along thoroughly rational lines, but with far different contours

[27] Ernan MCMULLIN, "Taking an Empirical Stance." In: MONTON, B. J. (ed.), *Images of Empiricism: Essays on Science and Stances*. New York: Oxford University Press 2007, p. 167–182; Jessica RISKIN, *Science in the Age of Sensibility: the Sentimental Empiricists of the French Enlightenment*. Chicago: The University of Chicago Press 2002, chapter 1; Thomas L. HANKINS, *Science and the Enlightenment*. Cambridge: Cambridge University Press 1985, p. 1–45.
[28] GOLDMAN, chapters. 10 and 11.
[29] Huston SMITH, "Scientism: The Bedrock of the Modern Worldview." In: ZARANDI, M. M. (ed.), *Science and the Myth of Progress*. Bloomington: World Wisdom Inc. 2003, p. 233–248.
[30] Edward GRANT, *God and Reason in the Middle Ages*. Cambridge: Cambridge University Press 2001. For what follows, see p. 148–202.

than the modern regime with which we are most familiar. Far from a discourse in which empirical data gathering, modeling, and testing are seen as the hallmarks of rationality, this was one in which systematic logic was *the* tool for knowledge creation and it was imagined that a good researcher could arrive at true knowledge about the natural world through the rigorous employment of the logical tools developed by Aristotle in the fourth century BCE and expanded by Arabic-language and Latin Christian intellectuals thereafter. It is true that this logical analysis of the universe was conditioned by common-sense observations of the world, for, as Albert the Great stated in his commentary on Aristotle's *Physics*,

> Everything that is accepted, which is confirmed by a [physical] sense is better than that which is contradictory to sense [experience]. In conclusion, that which is contradictory to a sense [experience] is not to be believed.[31]

In other words, one should examine the phenomenological world in order to develop logical analyses of how that world came to be, as well as how change in that world occurs, and any analysis that disagrees with what the senses convey must be rejected.

However, in the phrase of Edward Grant this was an "empiricism without observation," as it was part of the habitus for medieval natural philosophers that Aristotelian logic properly applied would lead to objectively true knowledge about the world. Such knowledge came as the result of properly constructed logic problems, not through any sort of testing or even data gathering.[32] This was due in large part to the place of Aristotelian logic in the medieval epistemic regime, as intellectuals held it to be something of a language of nature – and indeed the language of knowledge itself – in much the same way as a modern scientist would see mathematics.[33] This essay is an analysis of the way competing epistemic regimes make the use

[31] ALBERT the Great, *Alberti Magni Opera omnia, Physica, pars 2*. Hossfeld, P. (ed.). Aschendorff: Monasterii Westfalorum 1993, p. 587. "Omnis enim acceptio, quae firmatur sensu, melior est quam illa quae sensui contradicit, et conclusio, quae sensui contradicit, est incredibilis."

[32] Edward GRANT, *The Nature of Natural Philosophy in the Late Middle Ages*. Washington, D.C.: The Catholic University of America Press 2010, p. 195–225.

[33] Edith Dudley SYLLA, "Autonomous and Handmaiden Science: St. Thomas Aquinas and William of Ockham on the Physics of the Eucharist." In: MURDOCH, J. E, (ed.), *The Cultural Context of Medieval Learning: Proceedings of the First International Colloquium on Philosophy, Science, and Theology in the Middle Ages*. Dordrecht: D. Reidel Publishing 1975, p. 349–390, 350–352.

of value-laden terms such as science unwise and confusing rather than a discussion of medieval philosophy so I will pass over in silence the many points of disagreement that engendered heated arguments among medieval logicians, for those disagreements do not concern us here. The reason why is that despite such disagreements among those who shared this epistemic regime, which means virtually any educated person from the high middle ages until the early modern period – and beyond for many scholars – scholastics agreed that logically-constructed arguments led to the truth when properly constituted. The reason why logic held such power in the minds of medieval European intellectuals was the universally-held belief that cosmological order was the result of divine agency, which imposed that order in accord with logical principles. Therefore, divine order was infused in every part of the cosmos, and this order functioned and could be understood logically. In order to understand the place of this point in my argument, I will turn to the example of the rather surprising (to modern minds) role that astrology played in the thought of Albert the Great.

Albert was a Swabian-born Dominican who studied at Padua before earning his doctorate in theology at the University of Paris some time around 1250. This educational background is significant, for both of these schools were noted centers of Aristotelian learning in the thirteenth century.[34] Albert himself became so fascinated with Aristotelian philosophy, both natural and otherwise, that his fame among his contemporaries was largely built on his reputation as a knowledgeable commentator upon "the Philosopher," as Aristotle was generally known.[35] Therefore, Albert was one of the acknowledged masters of Aristotelian learning in the thirteenth century which was significant for two reasons: firstly, because this learning, or at least what medieval scholars understood this learning to be, provided the core of the habitus of the European intelligentsia of the period, secondly because the medieval epistemic regime was structured around Aristotelian philosophy. Within the Christianized Aristotelianism of the medieval period, God was identified as the prime mover that provided the actuating force

[34] James A. WEISHEIPL, "The Life and Works of St. Albert the Great." In: WEISHEIPL, J. A. (ed.), *Albertus Magnus and the Sciences*. Toronto: Pontifical Institute of Medieval Studies 1980, p. 13–53.

[35] BONAVENTURE d'Iseo, *Proohemium quarti operis of the Liber Compostellae Multorum Experimentorum Veritatis Fratris Bonaventura de Ysio de Ordine Fratrum Minorum*. In: GRABMANN, M. "Der Einfluß Alberts des Grossen auf das mittelalterliche Geistesleben." In: GRABMANN, M. (ed.), *Mittelalterliches Geistesleben*. Volume II. Munich: M. Hueber 1936, p. 324–412.

for all change in the universe, and this is where astrology became important to the system. Although Aristotle had not evidenced any great interest in astrology, the doctrine of efficient causation he presented in his work *On Generation and Corruption* began with the motions of the heavenly bodies, and he emphasized that the influence of the sun made both the "coming to be" of all earthly things as well as their "passing away" possible.[36]

Medieval astrology was, then, built on the premise that the supralunary world of celestial bodies in constant motion acted as God's intermediaries by influencing terrestrial events through the transmission of rays of light imparted with divine power.[37] Within this model, the human body was presumed to be a microcosmic representation of the larger macrocosm of the universe. Celestial motion, combined with the qualities of individual celestial objects, affected the human body by transmitting these light rays, thereby influencing human behavior and health in ways that could be understood through the study of astrology, which imparted knowledge about the impact of celestial forces on terrestrial objects through an analysis of heavenly portents.[38] According to Albert, there were "two great wisdoms," and though he is never as absolutely precise in his use of terminology as we might wish him to be, he clearly delineates the first as the field of pure astronomy while the second is the *"scientia* of the judgment of the stars."[39] While he deals with the first of these "wisdoms" in a rather cursory fashion whenever the subject arises, astrology so fascinates him that he returns to the topic repeatedly throughout his career. [40] And small wonder, because

[36] John D. NORTH, "Celestial Influence – the Major Premiss of Astrology." In: ZAMBELLI, P. (ed.), *'Astrologi Hallucinati': Stars and the End of the World in Luther's Time*. New York: Walter de Gruyter 1986, p. 45–100.

[37] ALBERT the Great, *De caelo et mundo*, *Opera Omnia*. Hossfeld, P. (ed.). Aschendorff: Monasterii Westfalorum 1971, p. 57.

[38] "Hae res omens [celestial motions] dicendae sunt in astrologia et determinandae sufficienter per principia mathematica." *Ibid*., p. 185. "In astronomia enim et in scientia electionum deo favente loquemur adhuc de stellis et determinabimus ea quae hic relinquuntur." *Ibid*., p. 154.

[39] ALBERT the Great, *Speculum astronomiae*. In: ZAMBELLI, P. (ed), *The* Speculum Astronomiae *and its Enigma: Astrology, Theology, and Science in Albertus Magnus and his Contemporaries*. Dordrecht: Kluwer Academic Publishers 1992, p. 208: "scientia iudiciorum astrorum." There has been, and continues to be, much discussion about the authenticity of Albert's authorship of this work, which I find to be completely unfounded as I discuss in Scott E. HENDRIX, *How Albert the Great's Speculum astronomiae was Interpreted and Used by Four Centuries of Readers: A Study in Late Medieval Medicine, Astronomy and Astrology*. Lewiston: The Edwin Mellen Press 2010, chapter I.

[40] Any comprehensive list of Albert's references to celestial influence would quickly grow to unmanageable proportions. For a representative view of his thoughts on the subject, see:

for Albert astrology is a "great wisdom" providing "a link between natural philosophy and metaphysics."[41] This is important for

> if God [...] has ordered this world [...] as to operate in created things [...] through stars [...] as if through instruments [...] what could be more desirable to the thinking man than to have a middle *scientia* [between natural philosophy and metaphysics] that may teach us how this and that change in the mundane world is effected by the changes in the heavenly bodies. [42]

Therefore, if the "thinking man" wishes to experience the creator there is no better way to do so than through a study of the way God works his will upon the earth through his celestial agents.[43]

Admittedly, Albert's emphasis on astrology and celestial forces sounds odd to modern ears, but that is precisely because the epistemic regime within which he functioned was vastly different than our own modernist one. Albert's view of knowledge production was one in which Aristotelian logic held pride of place and God's divine creation and ordering of the universe and all that it contains was an absolutely unquestioned part of the habitus of all European intellectuals. Therefore, Albert arrived at his understanding of astrology and its importance to understanding the world through his reading of Aristotle coupled with his study of theology and logical analyses of how these two fields of knowledge could be integrated – there was no empirical data gathering, modeling (mathematical or otherwise), or testing. Yet astrology, far from having the elements of superstition and irrationality that adhere to it as part of the discursive formation informing our modern language game, was cutting-edge natural philosophy in Albert's day, based upon principles that were universally acknowledged by the intelligentsia

ALBERT the Great, *De caelo et mundo*. Volume I, p. 150, 151, 153, *et alia*; ALBERT the Great, "De fato." In: *Opera Omnia*. Hossfeld, P. (ed.), Aschendorff: Monasterii Westfalorum 1975, p. 65–78; ALBERT the Great, "Problemata determininata." In: *Opera Omnia*. Weisheipl, J. A. (ed.), Aschendorff: Monasterii Westfalorum 1975, p. 45–64, 48–50; ALBERT the Great, "Questiones." In: *Opera omnia*. Froes, Albert (ed.), Aschendorff: Monasterii Westfalorum 1993, p. 59, et aliter.

[41] "Secunda magna sapientia, quae similiter astronomia dicitur, est scientia iudicorum astrorum, quae est ligamentum naturalis philosophiae et metaphysicae." *Ibid*., p. 218–221, chapter. 3.

[42] "Si [...] ordanavit Deus [...] mundum istum [...] velut operari in rebus creatis [...] per stellas [...] sicut per instrumenta [...] quid desideratius concionatori quam habere mediam scientiam, quae doceat nos qualiter mundanorum ad hoc et ad illud mutatio caelestium fiat corporum mutatione." *Ibid*., p. 220, chapter 3.

[43] *Ibid*., p. 220, chapter 3.

of Europe. Certainly, some such as the thirteenth-century bishop of Paris Stephen Tempier or the fifteenth-century chancellor of that same university, Jean Gerson, were suspicious of the attractiveness of astrology to their contemporaries but none denied its theoretical foundations.[44] In fact, by the end of the thirteenth century it was a mainstream part of the academic curriculum, with a well-developed set of theoretical justifications and held to be essential to the work of physicians as well as other learned professionals.[45]

The historical study of astrology is significant in the context of my current discussion, for many modern researchers refer to the discipline as a science, translating the Latin *scientia* (certain knowledge) in this way. However, here we should avoid ahistorical applications of such a loaded word. Astrology was indeed highly rational within the context of the medieval worldview, which is the likely reason why modern researchers influenced by the unconscious association of "logical" and "scientific" within the modern language game apply the term "science" to medieval astrology. Nevertheless, rather than a science it was just what medieval intellectuals held it to be, a branch of *philosophia naturalis*, or natural philosophy. The emphasis of all natural philosophy was indeed the natural world, a concern shared by the sciences, but the approach was always one of logical consideration that was connected to empiricism by only the loosest possible threads. Following Aristotle, medieval natural philosophers viewed *scientia* to be the grasp of principles that are true in and of themselves, explanatory of and prior to conclusions that are logical deductions drawn from those principles rather than the result of any sort of testing or data gathering, as exemplified by Albert the Great's approach to astrology.[46]

Perhaps just as importantly, natural philosophy was completely separate from mathematics, with the former dealing with material things as apprehended by the senses and the latter dealing with quantitative being, and never, ever, with material substances.[47] Sure, astrologers needed to be able to work out the math involved with understanding where heavenly bodies

[44] HENDRIX, chapter II.
[45] Nancy SIRAISI, *Medieval and Early Renaissance Medicine*. Chicago: University of Chicago Press 1990, p. 60–68.
[46] Paul T. SAGAL, "Naturalistic Epistemology and the Harakari of Philosophy." In: SHIMONY, A. (ed.), *Naturalistic Epistemology*. Boston: Kluwer Academic Publishers 1987, p. 321–333, 322–325.
[47] William WALLACE, "Traditional Natural Philosophy." In: SCHMITT, C. B. – SKINNER, Q. (eds.), *The Cambridge History of Renaissance Philosophy*. 6th printing,. Cambridge: Cambridge University Press 2003, p. 201–235.

could be found at any given time, or at least be able to understand the tables designed for such a purpose, but astrologers had little interest in mathematics *per se* and medieval mathematicians focused on their subject as a form of abstract knowledge utterly divorced from the phenomenological world.[48] Therefore, the medieval natural philosopher at work would most likely be found at his desk thinking deeply about a topic while constructing elaborately logical arguments based on a hegemonic discourse that emphasized Aristotle's philosophy as *the* explication of God's agency at work in the world. Within the medieval epistemic regime such an approach made perfect sense, for it was viewed as a given – in other words was part of the habitus of the medieval European intellectual – that knowledge of all things is to be found in the divine mind from eternity, therefore allowing for the uncovering of truth through an application of logic that brings the thinker closer to God's divinity rather than mucking about in the unclean and utterly un-divine material world.[49] Certainly a medieval scholar would consider things seen and observed, and Albert among others did go out of his way to gain first-hand knowledge of aspects of the phenomenological world ranging from meteorites to crystals, but such observations were tangential to the logical formulations that comprised the medieval construction of knowledge.

Modern researchers who have not taken these contextual considerations into account have repeatedly been led to ahistorical conclusions about what historical actors were thinking and doing. Moving away for a moment from medieval astrology, the best example of the cloudy vision of the past that has resulted from an approach that does not include the techniques of historical epistemology is to be found in Alistair Crombie's extravagantly positive analysis of the work of the thirteenth-century bishop of Lincoln, Robert Grosseteste. In his commentary on Aristotle's *Posterior Analytics*, Grosseteste stated that *scientia* is

> the comprehension of the truth of those things which always behave in a given manner, and in mathematics both the premises and conclusions are known in this way [...] Therefore, to know simply and most appropriately is to understand the unchanging cause of a thing in itself, [...] and this knowledge is the most

[48] Jan SALAMUCHA, *Knowledge and Faith*. Amsterdam: Rodopi 1993, p. 75–81.
[49] David G. LEAHY, *Faith and Philosophy: the Historical Impact*. Burlington: Ashgate 2003, p. 2–6.

special goal of this [metaphysics] and is acquired by demonstration most properly called.[50]

For Crombie this passage is proof that Grosseteste applied mathematical modeling to experimental procedures to arrive at certain demonstrations, but this interpretation is indicative of Crombie's training as a modern scientist who acquired the habitus of a modern epistemic regime. Eileen F. Serene has studied Grosseteste's writings with greater sensitivity to historical context than that exercised by Crombie, and she has concluded that what this passage and others point to is an emphasis on logical verification of natural phenomena rather than empirical testing.[51] Granted, Grosseteste felt that sense experience could inspire the higher human powers and he had an appreciation of mathematics' power to reveal natural truths that was well ahead of his time,[52] but in his approach examination of the natural world, the revelation of truth, and mathematics were not mutually reinforcing approaches, and nowhere in his method is there any form of testing aside from logical analysis.

The key point is that "science," as we understand that term today, is a methodology or set of methodologies that did not develop until the seventeenth century. The curious blending of experimental testing, mathematical modeling, and general theory formation came about through a series of social and historical processes that generate heated debates among scholars over their nature, the order in which they occurred, whether or not the process or end result was revolutionary, and a dozen other areas of contention unlikely to be settled any time soon.[53] But as with the debates of medieval scholars over the role and function of logic, it is unnecessary for us to consider these debates in detail, though we should briefly consider what it is about these developments that make for something so different in conception and execution that we may properly understand that a new epistemic regime came into being in this period. In other words, the proper processes of knowledge production, and even what "knowledge" is, were reinvented during this period beginning with the study of the natural world before spreading to

[50] Commentary on the *Posterior Analytics,* quoted in A. C. CROMBIE, *Robert Grosseteste and the Origins of Experimental Science*. Oxford: Clarendon Press 1953, p. 58–59.
[51] Eileen F. SERENE, "Robert Grosseteste on Induction and Demonstrative Science," *Synthese,* vol. 40 1979, no. 1, p. 97–115.
[52] James MCEVOY, *The Philosophy of Robert Grosseteste*. Oxford: Clarendon Press 1982, p. 167–170.
[53] For the best recent treatment of these debates, see H. F. COHEN, *The Scientific Revolution: A Historiographical Inquiry*. Chicago: University of Chicago Press 1994.

the epistemological systems of every branch of human knowledge. But even during this period commonly known as the Scientific Revolution, using the term science without proper regard for attendant discursive formations can act to cloud our understanding. In order to illustrate my point, I will focus on Galileo Galilei (d. 1642) both for the familiarity that readers will have with him as well as for the misunderstandings that have arisen about him due precisely to the work he did that has long since established him as an iconic figure in the development of science.

There is no doubt that Galileo will continue to be an important figure in the history of science, though his singular role in the development of the scientific method has been made far more complex by recent scholarship. While Alexandre Koyré was perhaps overly hasty in his emphasis on Platonism and metaphysics in Galileo's thought, not to mention his attempts to overturn the notion that experimental procedures played an important role in the Pisan mathematician's work, his attack on what has been called the "Galileo legend" bore fruit by leading others to examine more closely what it was that Galileo actually accomplished.[54] Far from decisively breaking with the approach of his predecessors and contemporaries, it seems that Galileo was altogether more willing to learn from developments occurring around him than has been imagined in the past, and clearly his reputation owes much to developments actually introduced by his followers.[55] However, thanks to more careful reading of Galileo's voluminous writings as well as modern reconstructions of experiments such as that of the inclined plane, it can no longer be imagined as Koyré once did that Galileo conducted experiments only in his head.[56] All of this is well and good, and certainly more in keeping with an approach that is respectful of the changing of epistemic regimes over time, but what was it that Galileo actually did?

As Winfred Lovell Wisan has remarked, developing an answer to the above question is not easy, because Galileo failed "to provide a systematic account of his views," instead leaving "brief comments on philosophy and

[54] Alexandre KOYRE, *Metaphysics and Measurement*. R. E. W. Maddison (trans.). London: Chapman and Hall 1968.
[55] See the essays in Jürgen RENN's *Galileo in Context*. Cambridge: Cambridge University Press 2001.
[56] Stillman DRAKE, *Galileo at Work: His Scientific Biography*. Chicago: University of Chicago Press 1978; Thomas B. SETTLE, "An Experiment in the History of Science." *Science*, vol. 133, 1961, no. 3445, p. 19–23.

method [...] scattered throughout his writings."[57] However, it is clear that the interest in mathematics, which he once called "the language of nature," that he shared with many of his contemporaries led him to seek to establish his work on the lines of "certain" demonstrations. Very often he felt that this was an impossible task, but in the attempt he did establish methods for showing that his ideas about motion (among other things) could be supported by applied demonstrations – or what we would now call experiments. Galileo himself viewed his mathematical propositions dealing with motion and the techniques applied to derive them as his most important contributions due to their capacity for "demonstrative discovery" of new propositions, as he termed it. For Galileo, one interested in uncovering the truth must begin with "evident principles," and thus the demonstrative experiments he developed were never intended to uncover the root causes of things, but in his quest for ever-more-sophisticated demonstrations he was constantly pushing into the realm of increasingly remote causes of things, leading to the uncovering of principles that were anything but evident. The result was that while he lacked any philosophical model of inductive knowledge formation based on hypothesis and experiment such as that which supposedly drives modern scientists, his work nevertheless followed a process of mathematical modeling, demonstrative experiment, and analysis that one would be at a loss *not* to call scientific.

However, Galileo also provides an excellent example of the dangers of assuming that the early modern epistemic regime within which he worked closely maps that of a modern one. This problem has arisen, in part, precisely because of the previously-mentioned "Galileo legend," which acts as a filtering prism through which modern people – especially modern scientists – view the work and ideas not just of Galileo himself, but often of any figure that has come to be associated with the Scientific Revolution.[58] No better example can be found than in the view that modern intellectuals have of Galileo's relationship to astrology. It has long been an article of faith among scholars that Galileo was a "constant adversary of divinatory astrology," to quote the historian Eugenio Garin.[59] This attitude toward Galileo has also

[57] Winifred Lovell WISAN, "Galileo's Scientific Method: A Reexamination." In: BUTTS, R. E. – PITTS, J. C. (eds.) *New Perspectives on Galileo*. Boston: D. Reidel Publishing Co. 1978, p. 1–58, 1. The rest of this paragraph comes from this source.
[58] Thomas M. LESSL, "The Galileo Legend as Scientific Folklore," *Quarterly Journal of Speech,* vol. 85, 1999, no. 2, p. 146–168.
[59] Eugenio GARIN, *Astrology in the Renaissance: The Zodiac of Life*[']. Jackson, Carolyn – Allen, June (trans.). New York: Routledge 1983, p. 10.

been common among both philosophers of science such as Karl Popper as well as scientists such as Carl Sagan.[60] Unfortunately, evidence is not on the side of this position. As long ago as 1881 the editor of Galileo's collected works, Antonio Favaro, published an article entitled "Galileo Astrologo," which has recently been translated and included in a special volume on *Galileo's Astrology* released by *Culture and Cosmos* in 2003.[61] Although Favaro's conclusions were tentative and he suggested that perhaps Galileo had lost interest in astrology as he aged, the evidence presented leaves the reader with no doubt that Galileo frequently cast horoscopes. This evidence ranges from the natal chart (a horoscope predicting an individual's future based on his or her time of birth or conception) Galileo cast for the Grand Duke Cosimo II of Florence to epistolary discussions of horoscopes in which Galileo engaged with important but distant figures such as the Cardinal Allesandro d'Este as well close friends such as Giovanfrancesco Sagredo.[62] Yet even today historians attempt to explain away Galileo's astrological pursuits as an activity intended to garner patronage from powerful people such as the Dukes of Florence,[63] quickly pass over it as an activity in which he "dabbled,"[64] or ignore it altogether.[65]

However, if we take the time to examine the horoscopes that Galileo cast there can be no doubt that he was completely earnest in his belief in the importance of the discipline. Turning to such evidence in MS. Gal. 81 we find not only horoscopes that could have been intended to garner the support of a patron – such as the aforementioned one for Cosimo II – but also those that Galileo did for himself, his daughters, and twenty as yet to be identified people.[66] Darrell Rutkin has devoted some time to analyzing the natal charts for Galileo's daughters as well as those cast for his friend Giovanni Francesco Sagredo, noting the care with which these charts are

[60] Karl POPPER, *Objective Knowledge: an Evolutionary Approach*. Oxford: Oxford University Press 1975, p. 176; "The Harmony of the Worlds." *Cosmos*, Carl Sagan, PBS 1980.
[61] Antonio FAVARO, "Galileo Astrologo." Evans, Julianne (trans.), *Culture and Cosmos,* vol. 7, 2003, no. 1, p. 9–19.
[62] *Ibid*., p. 11–13.
[63] Richard TARNASS, *The Passion of the Western Mind*. New York, Random House 1993, p. 295.
[64] Wade ROWLAND, *Galileo's Mistake: A New Look at the Epic Confrontation Between Galileo and the Church*. New York: Arcade Publishing, 2003, p. 295.
[65] Peter K. MACHAMER, *The Cambridge Companion to Galileo*. Cambridge: Cambridge University Press 1995, *passim*.
[66] H. Darrel RUTKIN, "Galileo Astrologer: Astrology and Mathematical Practice in the Late Sixteenth and Early Seventeenth Centuries." *Galilaena*, vol. 2, 2005, p. 107–143.

constructed. The purpose of such charts could not possibly have been to earn a fee or garner patronage, leaving us to see the care with which Galileo approached his work as an indication of the respect for the discipline in which he was engaged.

Clearly, the existence of this sizeable number of carefully-constructed horoscopes in Galileo's own hand demonstrates not only that the Italian scientist was quite familiar with the workings of predictive astrology, but also that when he did construct a chart he demonstrated both a great deal of care as well as ability. It is true that these horoscopes all seem to date to the late 1580s and 1590s while he was a professor of mathematics at Padua, but there is nothing to suggest that he changed his mind about the discipline after his appointment to the position of "Chief Mathematician of the University of Pisa and Philosopher and Mathematician to the Grand Duke" of Tuscany in 1610. Instead, it is just as likely that other concerns simply kept him too busy for such pursuits, especially since he became increasingly anxious to solidify his status as a philosopher rather than simply a professor of mathematics.[67] In the absence of evidence to the contrary we must assume that Galileo maintained his early interest in astrology throughout his life.

This point is not merely one of antiquarianism. The epistemic regime within which astrology was a rational part of the intellectual view of the world was one in which knowledge construction was based on working within a system built by foundational thinkers who saw the cosmos as an interlinked whole, as distant celestial bodies interacted with one another and the earth in entirely consistent and mathematically describable ways. Christian thinkers inherited the outlines of this system from Antiquity, building upon this foundation the version we encountered above by placing the beginning of the system of influences with God. However, Western theologians agreed that he did not ordinarily intervene in his creation thereafter. Therefore, the cosmos functioned with mechanical precision, as if it were clockwork in the phrase of the fourteenth-century intellectual Nicole Oresme.[68] This is the astrological system that Galileo inherited, and it is interesting to speculate upon the influence of the mechanical aspects of this model upon Galileo's own system of thought. If nothing else, interest in astrology and the desire to produce accurate horoscopes would have provided a strong incentive for

[67] Mario BIAGOLI, *Galileo, Courtier: The Practice of Science in the Culture of Absolutism*. Chicago: University of Chicago Press 1994, chapter 1.
[68] John NORTH, *The Norton History of Astronomy and Cosmology.* New York: W. W. Norton 1995, p. 265.

Galileo to think deeply about the motions of the heavens. Regardless of the positive influences that his role as an astrologer may or may not have had, though, one thing is certain: Whether astrological theory provided an impetus for Galileo's burgeoning mechanical philosophy or not, there can be no doubt that it is anachronistic to look for a rejection of astrology during this period as a sign of scientific rationalism.

By this point it should be clear that the application of the word "science" to the premodern world should be done only after the most careful consideration of not only what the researcher is analyzing, but also the place that this term holds within our modern epistemic regime in which "science" is part of a larger discursive formation. This formation is one that brings the concepts not only of "rational" and "scientific" together, but also "modern," "mathematical," and "empirically tested." Given the place of science in the modern world and the social capital it commands within the Western habitus, researchers should invoke the term to describe knowledge constructs prior to the seventeenth century only with the greatest care and hesitancy. This point has not gone wholly unacknowledged, as Alistair Crombie implied something quite similar when he argued that we must be "concerned above all with people and their vision," and acknowledged that words can have highly divergent meanings when employed within differing historical contexts, saying "experiment itself may have different meanings and intentions in differing contexts. We must approach our subject with an explicit cultural relativism."[69] A step in the right direction, surely, but Crombie would have done better to urge his readers to stick to the use of terms that do not do violence to the history he was trying to understand. Ultimately, what is at stake is not only the risk of imprecision, but a sort of modernist chauvinism that threatens to undermine any attempt to understand the past. This seems like too steep a price to pay for careless use of language.

[69] A. C. CROMBIE, *Styles of Scientific Thinking in the European Tradition*. Volume I. London: The Gerald Duckworth & Co. Ltd. 1994, p. 5.