Studies in History and Philosophy of Science

Stud. Hist. Phil. Sci. 33 (2002) 661–684

www.elsevier.com/locate/shpsa

A consideration of Babylonian astronomy within the historiography of science

Francesca Rochberg

Department of History, University of California at Riverside, Riverside, CA 92521-0204, USA

Received 26 March 2001; received in revised form 26 November 2001

Abstract

This paper traces the reception of Babylonian astronomy into the history of science, beginning in early to mid twentieth century when cuneiform astronomical sources became available to the scholarly public. The dominant positivism in philosophy of science of this time influenced criteria employed in defining and demarcating science by historians, resulting in a persistently negative assessment of the nature of knowledge evidenced in cuneiform sources. Ancient Near Eastern astronomy (and astrology) was deemed pre- or non-scientific, and even taken to reflect a stage in the evolution of thought before the emergence of science (in ancient Greece). Two principal objections are examined: first, that the Near East produced merely practical as opposed to theoretical knowledge and, second, that astronomy was in the service of astrology and religion. As the notion of a universal scientific method has been dismantled by post-positivists and constructivists of the second half of the twentieth century, an interest in varieties of intellectual and cultural contexts for science has provided a new ground for the re-consideration of Babylonian astronomical texts as science developed here.

Keywords: Babylonian astronomy; Cuneiform texts; Epistemology; Hellenistic astronomy; Religion and science; Theory

The rediscovery of the earliest evidence for the cultural and intellectual practice we term science is a relatively recent achievement in the history of scholarship. From the first readings of cuneiform astronomical texts in the late nineteenth century by Joseph Epping and Johann Nepomuk Strassmaier to the publication of *Astronomical Cuneiform Texts* by Otto Neugebauer in 1955 and the *Astronomical Diaries* by Hermann Hunger and Abraham Sachs from 1988 to 2001, it is clear that the process of decipherment and analysis of Babylonian astronomy has taken place over a span of

PII: S0039-3681(02)00022-5

time during which the idea of science itself has undergone significant changes. The history of science is necessarily influenced by an attendant view of science 'in general', even if that view regards science as an entirely culture-specific and therefore not a generalizable phenomenon.

Since a working definition of science for historians has become increasingly subject to criticisms stemming from criteria employed to identify and demarcate science in history, especially criteria established by modern Western standards, there seems to be little consensus any longer regarding such a definition. Efforts to understand science in history now reflect greater attention to cultural and social context, and so represent a more broadly historicist or even relativistic approach, as compared against the historiography of the first half of the twentieth century with its emphatic demarcation criteria. Accordingly, the place of Mesopotamian science within a general history of science has shifted with the change in historiography. Equally significant to the reevaluation of the status and character of Mesopotamian science in the wider context of ancient Mediterranean antiquity are recent changes in our understanding of the nature of Greek astronomy, and Greek science generally.

The aim of the following discussion is not to explicate particular Babylonian scientific texts or theories, but to address the historiographical issue of the reception of cuneiform astronomical texts into the history of science. The early stages of this history reflect text-book modernist ideas about the nature of science, ideas which, under the influence of a post-positivist orientation in the philosophy of science since the 1960s, have been problematized in the new historiography of science. The terms of my discussion will be familiar enough. It is not the 'historicization' of science or the break with old epistemologies *per se* which concerns this paper, but rather the history of the perception of Babylonian science as a result of these significant changes in the fields of the history and philosophy of science.

1. The reception of Babylonian astronomy into the history of science

Until the relatively recent turn away from the pervasive influence of the positivists upon historians of science, when the model of Western science provided the standard against which all other sciences would be judged, the ancient Greeks were assumed to be the inventors of science. In the history of astronomy, the recovery of the civilizations of the ancient Near East eventually necessitated the updating of the view of Greek astronomical science by acknowledging the Greek debt to their Near Eastern predecessors. Specifically, Greek astronomy came to be seen to depend in significant ways upon technical details borrowed from a Babylonian tradition.[1]

[1] Evidence, both literary and iconographic, of Greek awareness of Near Eastern tradition goes back to the Bronze Age, as documented in Morris (1992), especially Chapter 5, 'From bronze to iron: Greece and its oriental culture', pp. 101–149; see also Helm (1980) and West (1997). As far as astronomy is concerned, the transmission of mathematical astronomy appears to have occurred no earlier than the Hellenistic period (after 300 B.C.), but hints of earlier borrowings may be found, for example, in the Metonic cycle, see Goldstein and Bowen (1988), also Goldstein and Bowen (1983).

Despite the acknowledgement of an intellectual transmission from Babylonia to the Greeks, when it came to general histories of science, Babylonian learning (along with that of other non-Greek ancient sources such as those from Egypt, India and China) came to be contrasted with Greek 'knowledge' in one of two ways. What the eastern ancients 'knew' was categorized either as mere craft, developed out of practical necessity, or as theological speculation not anchored by logical, causal or rational inquiry into physical phenomena. In his paper in Marshall Clagett's well known 1957 'Critical Problems' conference, Alistair Crombie issued an authoritative formulation of this position:

> I do not think that the opinion that science is organized common sense or generalized craftsmanship and technology survives comparison with the actual scientific tradition, a tradition which seems to me to be essentially Western and to begin with the Greeks. Impressive as are the technological achievements of ancient Babylonia, Assyria and Egypt, of ancient China and India, as scholars have presented them to us they lack the essential elements of science, the generalized conceptions of scientific explanation and of mathematical proof.[2]

In *The Origins of Science* (1962), Hutten adopted the same stance with the statement that

> the philosophers of the Ionian school combined theorizing about the universe with knowing some facts and this made their work so unique and so fruitful. Eastern 'sages', too, were speculating about the world, but they were guided by religious and moral feelings rather than by the desire to understand external reality, while factual knowledge among the peoples of the Orient was mainly restricted to matters of everyday living, the concern of the artisan; thus the Orientals never developed science. Historically, Greek philosophy represents the first beginning of what we nowadays call 'science'.[3]

Similarly and during the same period, F. Sherwood Taylor, in his history of 'science and scientific thought', said

> we shall see how the practical recipes and records of the Egyptians and Babylonians gave place to the theoretical and philosophical science of the Greeks . . . The contribution of the Greeks was nothing less than the creation of the very idea of science as we know it. As far as we know, the Egyptians and earlier Babylonians recorded and studied only those facts about the material world that were of immediate practical use, whereas the Greeks introduced what is still the chief

---

[2] Crombie (1969), p. 81.
[3] Hutten (1962), p. 13.

> motive of science, the desire to make a mental model of the whole working of the universe.[4]

Of the two divergent characteristics, the practical and the theological, the more damning was the latter because it indicated an inability to employ rational faculties, if not a deficiency in the possession of them. Forbes and Dijksterhuis, in *A History of Science and Technology*, Vol. 1, *Ancient Times to the Seventeenth Century*, offered that

> [Ancient Near Eastern] Science, if we can call it such, only formed part of religious and philosophical wisdom. It did not construct a world-picture of its own built solely on the observations of natural phenomena and resting on certain supposed or established 'laws of nature'. Such a concept was totally foreign to pre-classical civilization; the world of the senses still formed part of the world as created by the gods 'in the beginning'.[5]

The same idea is echoed in Pannekoek's *A History of Astronomy* (1961):

> [The Babylonians] did not develop new geometrical world structures; they were not philosophical thinkers but priests, confined to religious rites, and therefore disinclined to adopt new cosmic ideas which did not conform to the holy doctrines. The planets to them were not world bodies in space; they remained luminous deities moving along the heavens as living men move on earth.[6]

As the above quoted statements show, a clear distinction between science and religion, and therefore also knowledge and belief, was an important device in the defining of science by the 1960s. The opposition rendered between reason and scientific knowledge on one hand and tradition, superstition and unscientific belief on the other informed a historiography which saw the necessity of a break with some religious or mythological tradition, such as the Homeric in the context of Greek culture, before the 'birth' of science was possible. Only then would the aquisition of (scientific) knowledge based on reasoned inquiry into empirical realities be possible, as opposed to the mere transmission of (religious) belief based upon apprehensions of natural or phantasmic phenomena in terms of the gods. The birth of science implied conceptual liberation from primitivism and a move upward along a Comtean ladder of human thought, and this important transition occurred first in Ionia. This view not only evoked an Enlightenment sensibility, but also a neo-evolutionist cognitive anthropology, as Near Eastern forms of inquiry into natural phenomena were

---

[4] Taylor (1963), pp. 3 and 20–21. Another practically identical statement is found in the introduction to Dampier (1946), pp. xiii–xiv.

[5] Forbes and Dijksterhuis (1963), pp. 15–16.

[6] Pannekoek (1961), p. 65.

deemed necessarily more primitive than Greek.[7] More will be said below (Section 2) on the interpretation of Mesopotamian expressions of interest in natural phenomena in terms of the divine as a certain and limited mentality or 'unscientific' mode of thought.

The evolutionary cognitive model seemed wholly consistent with the progressive view of science itself as a growing organism, ever advancing along its linear path together with the human mind.[8] This reconstruction carried the weight of authority by mid-century, and is to some extent still with us, albeit mostly in the pages of very general histories, for example, in the Penguin *History of Europe* (1996). There we are told that

> whatever its ultimate foundations and the mysterious forces embodied in them, the natural world and universe were for the most part logical and coherent in their working and could, therefore, be investigated by human reason. This assumption lies at the heart of European science, whose story begins in Ionia.[9]

Here, the attempt to pinpoint origins, to set the boundary between pre-science and science through an alleged break with tradition reflects the cognitive evolutionism that once saw science as the product of an advanced 'mind'. Again, Roberts:

> Why this happened is still obscure, but Ionian science signals a revolution in thought. It crosses a crucial boundary between myth and rationality. That boundary had been approached by earlier men; it can hardly be doubted (for instance) that the practice of architecture by the Egyptians and the knowledge they won empirically of engineering and manipulating materials must have revealed to them something of the mathematics of mensuration. Babylonian astronomers had made important observations in the service of religion, and carefully recorded them. Yet when we confront those Greeks in Asia Minor who first left evidence of their thinking about the natural world, they are already investigating it in a different, more detached way.[10]

Although these comments were not made by a professional historian of science, they nevertheless signal a persistent current in the historiography of science that retains not only a notion of science no longer widely accepted in today's intellectual climate,

[7] On the reemergence of evolutionism in American anthropology of the 1960s, see Trigger (1989), p. 292.

[8] The reification of science as a living organism was explicitly stated by George Sarton, who used the metaphor as a means of justifying less attention being paid to antiquity in teaching the history of science than to modern times thus: 'If the whole of science is considered as a continuous living body, which it is, moving with us toward the future, head forward, of course, and the tail trailing back to the beginnings, and if we have no time to study the whole beast, then we must concentrate our attention on the head rather than the tail. If we must let something go, let it be the past, the more distant past. Yet, it is a pity, a thousand pities' (Sarton, 1952, p. 59).

[9] Roberts (1996), p. 35.

[10] Ibid.

but also a putative but unsubstantiated non-Greek ancient mentality. On these bases, interpreters such as Roberts misapprehend the nature of Babylonian celestial science.

The etiology of Babylonian astronomy's early reception within the larger framework of science in history was, as I see it, twofold. The first reason stems from the classification of sciences, and therefore science in general, as established by Bacon and then by nineteenth-century writers such as Comte, Whewell and Spencer. This classification left a lasting imprint on the definition of science in terms of what ideas and what particular thinkers or developments were taken to constitute its history.[11] In consequence, as all of the above quoted passages illustrate, the classical Greeks had invented nature and natural principles, hence science, while a variety of non-Greek ancients were viewed as capable only of practical technology and religion, not science.

Perhaps even more determinative in the case of Babylonian astronomy, however, was the second reason, again nineteenth-century in origin, which stemmed from the history of astronomy itself. Shortly after the turn of the nineteenth century, the historical development of astronomy as well as actual historical astronomical data came to be of interest to the French, who then held a leading position in astronomical research.[12] The four-volume second edition of J. E. Montucla's monumental *Histoire des mathématiques* was published in 1802, and the two volumes of Delambre's *Histoire de l'astronomie ancienne* in 1817. Here the history of ancient astronomy was seen as a development of geometrical, specifically spherical, models of the motions of the heavens beginning with Eudoxus in the classical period, then Hipparchus and Ptolemy in the Greco-Roman, and finally Copernicus, Kepler and the conclusion of ancient mathematical astronomy with Newton. This astronomy was concerned primarily with planetary motion in a finite spherical universe and with reconciling cinematic planetary models of uniform circular rotation—whether about a central earth, sun or equant point—with the actual positions of planets observed in the heavens. As the rediscovery of the ancient Near East had only just begun, and cuneiform was still decades away from decipherment, Babylonia obviously had no part to play in this reconstruction of the evolution of astronomy which began in classical Greece and, by means of a process of preservation and emendation in Arabic astronomy, culminated in Europe.

On the other hand, the West associated the 'Chaldeans'— i.e., the Babylonians—with the practice of astrology. The Babylonian, or Chaldean, astrological tradition was already well known in Greco-Roman antiquity, but the disapproving attitude adopted in the West against astrologers had deep roots among the Biblical prophets, who had inveighed against 'the astrologers, the stargazers, the monthly prognosticators' (Is. 47.13). That the 'Chaldeans' were famed for the practice of astrology was also recorded, although without the derisive tone, in the medieval Arab scholar

[11] For example, Comte (1864), Whewell (1840) and Spencer (1874). For discussion, see Dolby (1979). The eighteenth-century background for this tradition in the French *philosophes* and the German Romantics is discussed by Cunningham and Williams (1993), p. 427 and n. 51.

[12] Neugebauer (1975), pp. 16–17.

Qādī Sā'id's description of what he knew of Babylonian celestial science in his 'Book of the Categories of Nations', written in A.D. 1068. He said:

> Among the Chaldeans, there were many great scholars and well-established savants who contributed generously to all the branches of human knowledge, especially mathematics and theology. They had particular interest in the observation of planets and carefully searched through the secrets of the skies. They had well-established knowledge in the nature of the stars and their influence.[13]

Despite the fact that ultimately Babylonian elements were transmitted through Indian sources of Islamic astronomy during the twelfth- and thirteenth-century European revival of astronomy in Islamic Spain, Babylonian astronomy itself remained unknown, and it was only the Chaldeans' astrological fame that held on into the Middle Ages and Renaissance.[14] Yet throughout the Middle Ages and Renaissance, while cuneiform tablets were still buried under ancient mounds, Greco-Roman astronomy, the heir to the Babylonian astronomical tradition, was preserved in the classical languages of Greek, Latin or Arabic, and as such entered the historical stream of European astronomy.

In the years immediately before and after the publication of Delambre's history of astronomy, there appeared in Europe two reports describing the remains of the ancient city of Babylon by Claudius Rich, the British agent for the British East India Company in Iraq and resident in Baghdad between 1808 and 1821. Rich's *Memoir on the Ruins of Babylon* (1815 and 1818) stimulated both British and French interest in the archaeological investigation of the mounds of Iraq, and efforts to decipher the cuneiform script were already under way. At this time, no one anticipated the consequences this new interest would soon have for the history of astronomy, because few were perceptive enough to have deduced the existence of a Babylonian mathematical astronomy from Greek, Greco-Roman or European sources.[15] Certain elements of Babylonian astronomy were embedded within European astronomy, such as the division of the circle into the 360 units we call degrees, the convention of measuring time as well as arc in the sexagesimal system, the zodiac, and a number of parameters such as the length of the mean synodic month (29;31,50, 7, 0^d), but their Babylonian origins were immaterial, as no one knew any longer to place these elements in a Babylonian context.

By the second half of the nineteenth century, scholars turned more intensively to the translation and analysis of the many cuneiform inscriptions which had poured into Europe from sites throughout Iraq. In the last two decades of the nineteenth century, the assyriologist Johann Nepomuk Strassmaier, working at the British Museum, copied the inscriptions on late Babylonian tablets, i.e. those dated to the

---

[13] Sā'id al-Andalusī (1991), p. 18.

[14] The survival of ancient 'Oriental' astrology through the Greco-Roman and Arabic inheritance of Renaissance (and Reformation) Europe was uncovered by early twentieth-century scholars such as Franz Boll, Carl Bezold, Franz Cumont and Aby Warburg.

[15] Tannery (1893, p. 185) was one of the few, as noted by Jones (1993), p. 78.

last half of the first millennium. For the many tablets consisting largely of numbers, month names and technical terms unknown to him, Strassmaier secured the help of Joseph Epping, a professor of mathematics and astronomy. The result of their collaboration was the discovery of a mathematical astronomy in the tablets found in the two cities of Babylon and Uruk. The remarkable contribution of Epping and Strassmaier to our knowledge of ancient civilization was published in 1881 in a short paper in the Catholic theological journal *Stimmen aus Maria Laach*, and was later described by Otto Neugebauer as 'a masterpiece of a systematic analysis of numerical data of unknown significance'.[16]

This was a positional astronomy of a completely different sort from any other ancient astronomy then known. It differed from the tradition of the *Almagest* and its descendants in its goals, methods, and in the nature of its planetary and lunar theory, yet the analysis of Babylonian mathematical astronomy led to the realization of its connection to Greek astronomy and by extension the entire tradition of European astronomy. Indeed, a number of parameters attested in Ptolemy's *Almagest* and in many astronomical papyri were finally identifiable as of Babylonian origin.[17]

The legacy of Babylonian astronomy in Greek, Indian, Arabic and European astronomy was demonstrable, but differences were also discernible between Babylonian astronomy and its Western descendants. Babylonian astronomy did not rely or depend upon a spherical cosmological framework, nor did it make use of geometrical models of a celestial body in motion around a central earth, although celestial coordinates, primarily degrees of ecliptical longitude and latitude, were used. Its goal was not to devise a model of a planet's motion such that visible synodic phenomena, such as first and last visibilities, stations and retrogradations would be secondarily derived from the model; rather, the synodic moments, and particularly the horizon phenomena of risings and settings, were central and any position of the body at arbitrary moments in between the special appearances would be derived by interpolation. In contrast to the interest in the position (geocentric ecliptical longitude) of a celestial body at some given time t, later to be developed in one of the branches of Greek astronomy, the Babylonian interest was in the position (geocentric ecliptical longitude) of a celestial body when t is one of the planet's synodic appearances (or disappearances).[18]

Underlying the Babylonian astronomy was an understanding of and arithmetical control over the variable 'velocities' (progress in longitude over a certain period) of the sun and planets in the planetary theory (or sun and moon in the lunar theory) as well as the variable inclination between ecliptic and horizon throughout the year (a problem of spherical astronomy), and also visibility conditions near the horizon where most of the synodic appearances occur. What was of prime interest, therefore, was the 'synodic arc', that is, the distance in degrees of longitude traveled by the planet (or moon) between consecutive phenomena of the same kind, such as from

[16] Neugebauer (1975), p. 349. Epping's article of 1881, with an introduction by Strassmaier, was followed in 1889 by his *Astronomisches aus Babylon* (Epping, 1881, 1889).

[17] Aaboe (1955–56), pp. 122–125.

[18] Neugebauer (1955, 1975).

first visibility to first visibility. The synodic arc, defined as the progress in longitude of a body in a particular synodic phenomenon, was, in one method, generated by a piecewise constant step function of longitude, and in another method was represented as a periodic zig-zag function of the number of the synodic phenomenon in a certain sequence.[19]

In each method, the mathematical model of the synodic arc was anchored to the ecliptic, and excellent values of relevant planetary and lunar periods, such as the sidereal year, the synodic and sidereal periods of all the planets as well as the synodic, anomalistic and draconitic periods of the moon, giving quantitative dimension to the models. An important component of the success of these essentially predictive theories of planetary and lunar phenomena was an understanding of the relations between the relevant periods. Indeed, as Neugebauer often put it, 'period relations . . . form the very backbone of Babylonian mathematical astronomy'.[20] Suffice it to mention the '19-yr luni-solar calendric cycle' in which 19 years = 235 synodic months, or the famous '18-yr Saros cycle' underlying Babylonian eclipse theory in which 18 years = 223 mean synodic months.[21]

Even after Neugebauer's publications of the 1940s and '50s disseminated knowledge of Babylonian astronomy to a wider scholarly public,[22] the reception of these new sources within general histories of science was not commensurate either with their character or significance. The revised second edition of J. L. E. Dreyer's *A History of Astronomy from Thales to Kepler*, for example, took no notice of the findings of scholars who had worked on cuneiform astronomy. In the Foreword to the revised edition of 1953, W. H. Stahl noted that

> one of the chapters, the Introduction, is notably deficient. Instead of treating the scientific aspects of early oriental astronomy—which would have been in keeping with the rest of the volume—he preferred for some strange reason to handle the childish cosmological conceptions. Kugler's pioneer work in deciphering Babylonian astronomical texts was known to him, but he made limited use of it. He does not refer to the Babylonian studies of Epping. Like many other historians of occidental science, Dreyer seems to have been reluctant to acknowledge the full extent of Babylonian influence upon Greek astronomy and mathematics. . . . Readers who desire to survey our present knowledge about Babylonian and Egyptian astronomy and mathematics will find summary treatment in the publications of Neugebauer, which since World War II, have been appearing in English.[23]

For historians of astronomy as of science in general in this early post-war period,

[19] A concise and lucid description of the Babylonian computation of the synodic arc (¢Ï) and its general theory may be found in Aaboe (2001).

[20] Neugebauer (1969), p. 102.

[21] Neugebauer (1975), pp. 502–506.

[22] See especially Neugebauer (1957), and Neugebauer (1955), as well as many articles in the *Journal of Cuneiform Studies* of the 1940s.

[23] Dreyer (1953), pp. vi–vii.

the reputation of the Babylonians as astrologers was still strong, only now it was known that the astrologers were possessed of a quantitative and predictive astronomy. Outside the ranks of specialists, however, the mathematical astronomy of the late Babylonian texts did not bring about a reconsideration of the nature of ancient astronomical science, much less of science in general. Rather, it became necessary to argue that while Babylonian astronomy was technically sophisticated, its achievements did not have any impact on the kind of 'thought' associated with science in the West, namely abstraction, axiomatic logic, demonstration or mathematical proof.

Even some fairly specialized works, such as the widely received *Science Awakening II: The Birth of Astronomy* by B. L. van der Waerden (1974), testify to the widespread acceptance of this view of science. Van der Waerden, a scholar whose contribution to the history of Babylonian astronomy is substantive and sizeable, nonetheless judged Babylonian mathematical astronomy as not 'theoretical', as compared against Ptolemy's *Almagest*, and his justification was that 'the principal motive of the Greeks in developing their scientific astronomy was not the astrological application, but rather a specific interest in astronomy itself'.[24] As recently as 1993, in O. Pedersen's *Early Physics and Astronomy*, ancient Near Eastern thought was found to be deficient in aspects considered to be essential to science:

> Archaeology has shown the extent to which pre-Greek civilizations were dependent upon technology and mathematics. This seems to prove that exact science came into being before the Greeks. In a sense, this is true, but both Egyptian and Babylonian science and mathematics were . . . very different from those of the Greeks. A finer investigation reveals that the achievements of the Egyptians, and of successive peoples in Mesopotamia, were very closely related to the practical demands of everyday life, and involves none of the elements considered today as essential to science: the evidence so far suggests that these peoples knew nothing of logical proof or of natural laws.[25]

In a similar vein, Alioto concluded:

> Predicting the phenomena added nothing to understanding them, making them intelligible. The application of rigorous methods to an understanding of nature was yet many centuries away. This is our method, and although we see the rudiments of it in the ancient Near East, we must realize that these people's picture of nature, their 'science', came from other sources. Speculation was confined to the realm of myth, and though this strikes us as totally 'unscientific', it is still speculation based upon the need to explain experience. And this it did quite well. It is only when man begins to desanctify nature, speculate upon the 'it', that the use of reason comes into play. This we owe to the Greeks.[26]

---

[24] van der Waerden (1974), p. 2.
[25] Pedersen (1993), p. 5.
[26] Alioto (1987), pp. 19–20.

These statements attest to the persistence of the view, characteristic of the early to mid twentieth century, that, although Babylonian astronomy was quantitative and predictive, it nonetheless participated in the 'sanctification' of nature, and so was not yet science. While the content of the cuneiform astronomical ephemerides was clearly something other than 'religious speculation', it was produced by a group of *literati* holding priestly titles and carrying out their work within the institutional framework of the great temples of Babylon and Uruk.[27] To account for this position as sheer Whiggism, though, would be to mistake the result for the cause. The reason rather lies in the interpretation of the Babylonian inquiry into natural phenomena, as already indicated above, either as a matter of practical or merely technical understanding, or as a form of (or influenced by) religious speculation, which, by definition, lacked reason and logic. It is interesting to note in this context that a similar incompatibility between magic and philosophy was brought to bear on the analysis of, for example, the hellenistic Neo-Pythagoreans, who were associated with a variety of doctrines on the medical and magical properties of planets, animals and stones.[28] Here, a persistent evolutionism manifests in the following interpretation of late Pythagoreanism as a degeneration of Greek rational science.

> A fundamental characteristic of this Hellenistic wisdom is that it was intensely *practical*: it aimed at control of the world, not at disinterested understanding. That indeed distinguishes it from the great rival tradition of Aristotle, in which *theoria*, the knowledge and contemplation of things for their mere beauty and order, is the goal of science. Practical arts lie at the origins of Hellenistic wisdom, and it was the interaction of the Greeks with the cultures and skills of the lands which Alexander had won that brought them into being . . . [This new] science was always intensely practical and exploitive—Nature's sympathies and antipathies were there to be *used*—and that is why its manifestations . . . seem more magical than scientific even in a debased sense.[29]

Not only are Hellenistic natural philosophy and magic here judged on the basis of their practical nature to represent an epistemological decline from the great tradition of Aristotle, but blame for the corruption of Greek science is placed 'with the cultures and skills of the lands which Alexander had won', that is, with Orientals generally, but certainly with the Babylonians.

2. Philosophical influences

The negative assessment of the nature of knowledge in ancient Mesopotamia reflected in the historiography of science of mid-century and the generation follow-

[27] See Rochberg (2000), pp. 359–375.

[28] Such doctrines in fact are traceable to ancient Mesopotamia, for which see Reiner (1995), Chapter 2, 'The art of the herbalist', pp. 25–42.

[29] Emphasis is in the text. See Beck (1991), pp. 496, 559–560 apnd Kingsley (1995), pp. 336–337.

ing, as illustrated in the passages quoted in Section 1, can be partly attributed to the widespread influence of the logical-empiricist school of philosophy of science, admittedly oftentimes disseminated in over-simplified ways. The influence of the philosophical concerns basic to logical empiricism may be found in the background of each of the claims, discussed in Section 1 above, namely, that ancient Near Eastern natural inquiry was incapable of creating or supporting science, first, because it produced practical knowledge, manifested in evidence of starlists and calendar-making instead of astronomical theory, and second, that it approached natural phenomena as a means by which to communicate with the divine, manifested in the predominance of astrology over astronomy. These can be construed as separate objections, the former being an epistemological problem configured around a dichotomy between practical and theoretical knowledge, the latter being a problem of aims, in which astronomy was compromised by association with astrology and the desire to communicate with the divine. Viewed in this way, Babylonian astronomy, in the period of its early reception into the history of science, seemed to have been conceived of as stuck between the too mundane and practical on one side and the too religious and metaphysical on the other. Both objections, however, coalesced to form an assessment of a Babylonian mode of thought, on the one hand as non-theoretical (hence cognitively ordinary as opposed to scientific) and on the other as non-rational (i.e. religious as opposed to scientific). Although I have separated these objections for the purpose of clarification, they are clearly related and interdependent.

2.1. Practical knowledge: the epistemological problem

Characteristic of classic philosophy of science, through the intellectual patrimony of the logical positivists, was a focus on, as Ernan McMullin put it, ‘natural science as a highly specific mode of knowing and of explaining . . . There was a logic underlying the methods of validation and of explanation in science and the task of the philosopher was to disengage this logic once and for all’.[30] In historical terms, the development of systematic and critical methods of knowing out of and beyond mere common sense has been attached to the evidence of Greek philosophy, beginning in the sixth and fifth centuries and culminating with Aristotle. This distinction was clearly drawn in Marx Wartofsky’s *Conceptual Foundations of Scientific Thought* as follows:

> The tension between theoretical construction and common sense, between hypotheses framed to answer the questions of the speculative intellect and the plain facts of everyday know-how and observation thus gives rise to a criticism of a more complex sort. For our purposes, in examining the genesis of scientific thought, this is crucial. For it marks the radical transformation of acritical common sense into critical, rational scientific thought. It is not accidental that the earliest instances of philosophical speculation and criticism and the earliest instances of

[30] McMullin (1988), p. 1.

> rational natural philosophy are one and the same . . . Out of this amalgam the Greeks fashioned a conceptual revolution so profound, so decisive in its impress that the main features of scientific thought—what we here call its conceptual foundations—retain to this day the features of that mold.[31]

Later, of course, some philosophers of science, principally Kuhn and Feyerabend, called for a more historical and less epistemological grounding of science. Even Feyerabend, however, while accusing the ‘rational account’ of scientific change of failure, granted that

> The sciences and especially the natural sciences and mathematics seem to be theoretical subjects *kat’exochen*. They arose when Greek theoretical traditions replaced the empirical traditions of the Babylonians and the Egyptians.[32]

Given the overwhelming presumption in the philosophy of science that ancient science meant Greek science, the importance of the philosophy of science to the reception of Babylonian astronomy into the history of science is obviously not found in any direct discussion of Babylonian material by philosophers, but in the creation of the criteria by which cuneiform scientific texts would be considered by those interested in the question of the relation between Babylonian science and science in general. Reflecting the central concerns of the philosophy of science in the era dominated by logical positivism, these criteria were epistemological, and were designed to describe the nature of scientific theory and thereby to demarcate science and its ‘thought’ from non-science.[33]

We have seen, in the early histories of astronomy, quoted above in Section 1, the argument that Babylonian astronomy was not truly theoretical by virtue of its predictive goals and its manifest differences from Greek astronomy. In the judgment of these histories, the relationship between Greek and Babylonian astronomy paralleled the distinction between Greek thought and that of its ‘Oriental’ predecessors, i.e., that the former was abstract, general and, therefore, theoretical, while the latter remained concrete, particular, and so merely predictive. Such was the understanding of Pedersen, who lauded the ‘amazing perfection’ of the arithmetical methods of Babylonian planetary astronomy, but said that the numerical schemes were not accompanied by any connected ideas of the physical structure of the universe. Here Babylonian astronomy was strictly phenomenological although as equally successful as the geometrico-physical astronomy of the Greeks. Nevertheless, the art of developing theories based upon physical models seems to have been unknown.[34]

The characterization as ‘strictly phenomenological’ was a comment on the absence

[31] Wartofsky (1968), p. 68.

[32] Feyerabend (1981), p. 11.

[33] This is not the place to engage in a review of specific hegemons of logical empiricism (Carnap, Reichenbach, Hempel), but discussion of the legacy as well as the demise of this philosophy of science may be found, for example, in Giere (1988), or Salmon (1998).

[34] Pedersen (1993), pp. 5–6.

of explanation or of a deductive relationship between theory and predictions. But the particular data generated in the cuneiform tables were the results of quantitative manipulation of a number of general methodological schemes, the two primary ones now dubbed System A and System B, which could be applied to any phenomenon of any planet, the results of course depending upon the use of excellent parameters for a given phenomenon. The lack of an explicit cosmological model within which Babylonian astronomical theory was to fit was of no consequence in view of the fact that the predictions did not derive from a geometrical conception that attempted to make causal sense of the phenomena, but rather depended upon period relations whose purpose was to enable the computation of phenomena either forward or backward in time in an instrumental way. Exemplifying this kind of theoretical orientation are prediction rules for calculating the highly variable time intervals between moonrise and sunset, sunrise and moonset at opposition, which values require a solid grasp of the periodic progress of the moon in relation to the sun and the relationship of this to the variable inclination of the ecliptic and lunar path with respect to the horizon. These rules may be checked against modern computation with excellent agreement.[35] The development of Babylonian astronomical knowledge and the methods to deal with it was surely a long process, involving most of the features of inquiry familiar to inductive science in the standard sense, i.e., observation, 'hypothesis' construction, and the introduction of 'theoretical entities' specific to the theory of phenomena in a certain domain (such as lunar or planetary synodic phenomena) which do not themselves have direct correspondence in the physical world (such notions as mean synodic progress in longitude). It must be admitted, however, that the interaction between observation and theory construction remains a murky area of our understanding of Babylonian astronomy,[36] although it is not likely that the generation of data by computation in the ephemerides was for the purpose of checking against observed data.[37]

Another epistemological issue at stake for classic philosophy of science was the special cognitive status of 'theoretical' knowledge, hence theoretical thinking, i.e., that it differed in kind from 'ordinary' knowledge, the product of 'ordinary' thinking. With the emergence of science from pre-science, so too did scientific (read theoretical) thought emerge from a stage of cognitive development within which 'science' does not and cannot exist. Deanna Kuhn, however, has argued for the epistemological sophistication of scientific thinking and the 'non-trivial differences between everyday and scientific thinking', but not for scientific thinking as an evolutionary achievement, rather a function of special training.[38] In her view,

> it is a mistake to equate good or rigourous thinking with scientific thinking. To do so is to view the scientific enterprise and the thinking associated with it much

---

[35] Brack-Bernsen (1999), pp. 172–175.

[36] Evidence for the empirical grounding of Babylonian lunar theory is discussed in Britton (1993).

[37] For the possibility that computed phenomena in one extant astronomical text were for the purpose of the construction of horoscopes, see Steele (2000), p. 132.

[38] Kuhn (1996), pp. 261–281.

> too narrowly. Scientists employ the inferential thinking strategies that they do because they are powerful strategies that well serve the scientist's objectives. It does not follow that such strategies should be confined to or even associated predominantly with science . . . In carving the modes-of-thinking pie, then, the first cut, in my view, is not between scientific thinking and another form or forms that might be characterized variously as narrative or associative or creative. Instead, the most significant distinction to be made is between thinking that is more versus less skilled, with skilled thinking defined in its essence as thinking that reflects on itself and is applied under the individual's conscious control.[39]

Such an argument would mitigate *a priori* claims that ancient Near Eastern inquiry into natural phenomena could not have taken 'scientific' form. In support of this idea we observe that the astronomical theories and methods of Babylonian scholars were indeed the product of trained specialists and the body of texts in which these theories, methods and their results were transmitted, the ephemerides, were the province of a trained elite group.[40]

The argument against the theoretical status of Babylonian planetary and lunar tables, as cited above, was often made by pitting Babylonian astronomy against Greek and claiming a disparity between them precisely on the basis that the former was quantitative but not theoretical (lacking explanatory force), while the latter was theoretical and, at least from the *Almagest* onward, quantitative.[41] A presumed dichotomy between 'Babylonian' and 'Greek' astronomy, however, fails to take account of Greek papyri or Sanskrit materials that continued the linear methods of the Babylonians.[42] This position, however, has been finally rendered obsolete for the non-specialist by the recent publication by Alexander Jones of the astronomical papyri from Oxyrhynchus, the latest and most important of Greek sources for the history of astronomy.[43]

The quantitative contents of the papyri reflect the contemporary practice of technical astronomy during the late Greco-Roman period and, as such, determine geocentric longitudes of the sun, moon and five naked-eye planets for a certain date, and also determine the dates (and even sometimes time) of entry of the planets into the zodiacal signs, both of which goals clearly serve the needs of astrologers constructing horoscopes. Whereas Greco-Roman astronomy has been closely identified with the Alexandrian tradition that culminated in the second century A.D. with Ptolemy's *Almagest* and its exposition of geometrical (or kinematic) methods to account for the motions of the planets, Jones has shown that 'in contrast to the modern conception of Greek astronomy as a theoretical enterprise, the papyri portray a science that was

39 Kuhn (1996), p. 276.

40 See note 27, above.

41 Goldstein and Bowen (1991) establish a new dating for the introduction into Greek astronomy of quantitative elements (such as degrees) and the basis for a quantitative dimension of astronomical theory in dated observational data.

42 See Pingree (1973, 1981).

43 Jones (1999).

overwhelmingly directed towards prediction'.[44] Not only does the new edition of the papyri demonstrate the predictive character of a large part of Hellenistic Greek astronomy, but it gives us dramatic evidence of the preservation until the fifth century of Babylonian predictive methods in Greco-Roman astronomy. While an ancient Near Eastern foundation for Greco-Roman astronomy has long been beyond dispute, the nature of the Babylonian legacy has been viewed as one of preserved elements within a system fundamentally different from that associated with the cuneiform ephemerides. Such elements are the sexagesimal number system, excellent Babylonian parameters and period relations, as well as a number of observations embedded in the Almagest.[45] Despite such lasting foreign elements within Greek science, it appeared that the arithmetical methods of the Babylonian tablets had been all but superceded by the Greeks' geometrical cinematic models. The geometric spherical models of planetary motion exemplified in the *Almagest*, which in general histories of science previously were represented as the characteristic feature of Hellenistic astronomy, must now be recognized as one of two methods characteristic of the astronomy of the period, the other being the description of the behavior of the planets by means of a variety of linear arithmetical sequences originating with Babylonian mathematical astronomy. Consequently, a hitherto unacknowledged disunity in the methods and goals of ancient Greek astronomy must now be recognized.

The Oxyrhynchus papyri provide powerful ammunition for relativist historians and philosophers of science who prefer to study science and its theories empirically, through the historical record, and to construct, or reconstruct, science accordingly. The Greek astronomical papyri do not undermine the assessment of the theoretical character of the cinematic model-making form of ancient astronomy, but in showing that Greek astronomy was methodologically more diverse than previously acknowledged they mitigate any attempt to draw cognitive historical conclusions about the nature of the Babylonian 'mind' in contradistinction to the Greek, or our own.

2.2. Religious aims: the pragmatic problem

The second angle from which Babylonian astronomy was judged unscientific was that which saw astronomy in the service of divination and astrology. In this sense, astronomy was not scientific but 'religious', insofar as it enabled communication with the gods. Indeed, Babylonian astronomy belonged to an intellectual tradition of diverse content, including divination, magic, incantation and medical texts.[46] The extensive omen lists, the celestial omen compilation *Enūma Anu Enlil*,[47] among others, compile in systematic arrangements all manner of physical phenomena within the world of human experience. A divine immanence in that world is conveyed in some of the descriptions of phenomena in which clearly some gods were conceived of as manifested *in* celestial phenomena, such as the lunar eclipse viewed as the

[44] Jones (1999), p. 5.
[45] See Toomer (1988).
[46] See Rochberg (in press a).
[47] For a summary of the sources and their contents, see Hunger and Pingree (1999), pp. 5–22.

moon god Sin, 'covered' in mourning, or thunder as the voice of the storm god Adad.[48] While more often phenomena were referred to without a hint of divine embodiment, the very idea of an omen serves to remind us that for the ancient Mesopotamians, all physical existence and the divine sphere of influence were coextensive. Accordingly, all phenomena, including those above (in the sky) as well as those below (on earth), were subject to interpretation as signs, and such signs, in the Babylonian view, were brought about through divine agency as a manifestation of the gods' concern for human beings. Divination afforded indirect communication between man and god, to the benefit of man, in that steps could be taken to avert the bad consequences of omens through apotropaic magic, termed *namburbû*.[49]

Any investigation of the intellectual context of the exact sciences in ancient Mesopotamia must give due consideration to the ways in which disciplinary boundaries may have been conceived, in particular whether such boundaries existed, for example, between 'astronomy' and 'astrology', in any way akin to our own. We turn here from an epistemological problem regarding the nature of astronomical knowledge, to one of the motivations and goals of astronomy. The two concerns are closely connected inasmuch as the attribution of religious motive and the consequent 'theological' conceptualization of the celestial phenomena, for example as manifestations of deities, has been taken as evidence for a non-rational mode of thought about that world of phenomena, as discussed in Section 1.

Behind the charge that Babylonian astronomy was unscientific (or pseudoscientific) were the influences of both the conflict model of the relation between science and religion and also the evolutionary scheme that put science as a later development, even a liberation, from magic and religion. Of course, for historians of Western science in the early to mid twentieth century, who transferred modern demarcations between sciences and pseudo-sciences to the pre-modern world, astrology was 'spiritual' as well as 'occult', and therefore located on the margins of science proper. As long as the study of astrology was regarded as tainted or primitive science, however, our ability to reconstruct and interpret the history of ancient astronomy remained not only partial, but plainly ethnocentric. Recognition of the complexity of Mesopotamian interest and investigation of celestial phenomena underscores just how distorting it was, in early treatments of the Mesopotamian approach to nature, to allow cosmogonic mythology to stand in for astronomical source material as evidence for 'Mesopotamian thought' about nature. The focus on mythological texts, not surprisingly, supported the idea that 'mythopoeic' thought was characteristic of the ancient Near East, and promoted the image of an ancient Mesopotamian 'mentality' in non-specialist histories of science, such as those quoted in Section 1 above.

The *locus classicus* for the analysis of the alleged traditional 'mentality' was Henri Frankfort's well known and widely quoted *Before Philosophy: The Intellectual Adventure of Ancient Man*, which said:

---

[48] For discussion, see Rochberg (1996), pp. 475–485; also Rochberg (in press b).

[49] Maul (1994).

> When we turn to the ancient Near East . . . we find that speculation found unlimited possibilities for development; it was not restricted by a scientific (that is, a disciplined) search for truth . . . For them nature and man did not stand in opposition and did not, therefore, have to be apprehended by different modes of cognition . . . The fundamental difference between the attitudes of modern and ancient man as regards the surrounding world is this: for modern, scientific man the phenomenal world is primarily an 'It'; for ancient—and also for primitive—man it is a 'Thou'.[50]

Frankfort generalized from the evidence of cosmogonic mythology to a cognitive stage of development in human thought, one which could not 'become part of a progressive and cumulative increase of knowledge',[51] in other words, one incapable of producing 'science':

> We are here concerned particularly with thought . . . we cannot expect in the ancient Near Eastern documents to find speculation in the predominant intellectual form with which we are familiar and which presupposes strictly logical procedure even while attempting to transcend it.[52]

Frankfort's analysis harks back to a nineteenth-century rationalist perspective, such as that exemplified by Sir James Frazer's *The Golden Bough*, in which humanity's relation to nature evolves from one expressed through magic, followed in genealogical descent by a refinement to religion, and finally to science, or indeed by Comte's scheme of the religious, metaphysical and finally positive society.[53] From such evolutionist ideas stemmed the claim that in antiquity the human mind was capable only of the (primitive) magical understanding of the world. If, by modern criteria of logic, instrumentality and rationality, magic is classified as irrational, then the ancient mode of reasoning must be irrational.[54] With no argument to support the use of myths as evidence for a Mesopotamian cognitive history, the 'mythopoeic thought' thesis purported to deduce a 'mode of thought', an irrational one at that, as well as a stage of cognitive development from evidence belonging to religious or ritual expression. The problem of deducing from expressions of a religious or ritual nature a mode of thought, not to speak of an evolutionary stage of cognitive development, was already of concern to Frankfort's contemporary, Malinowski, who described the concurrent existence within any society of a practical/rational outlook with a sacred/'mystical' one.[55] The evolutionism inherent in this early approach to 'mentalities' constituted

---

[50] Frankfort, Frankfort, Wilson, and Jacobsen (1949), pp. 12–15.

[51] Frankfort et al. (1949), p. 251.

[52] Frankfort et al. (1949), p. 14.

[53] On evolutionism and nineteenth-century rationalism, see Vickery (1973), p. 18. See also the comments in Lloyd (1990), p. 39.

[54] See Horton (1993), pp. 105–137, in the section 'Back to Frazer?', especially pp. 127–132.

[55] Malinowski (1954), pp. 26, 34–35; see also Lloyd's comments on the concurrence of these 'mentalities' even in modern society, in Lloyd (1990), pp. 40–42.

one of its chief problems,[56] as it seemed to stem from ethnocentrism, on one hand, and led to simplistic dichotomies, such as 'traditional' and 'modern', on the other.

The continuing influence of Frankfort's theory, however, is felt in a 1992 article by Frans Wiggerman, who stated: 'If nature is defined as a machine lacking free will, there is no nature in Mesopotamian thought'.[57] While Wiggerman's description is sound in its aim to differentiate the Mesopotamian attitude toward physical phenomena from our own, he nonetheless perpetuates a Frankfortian view of a Mesopotamian mode of reasoning in his further clarification that

> The assumption underlying my contentions is not that the inhabitants of Mesopotamia could not think, but that they did not do it often . . . The simple fact that the documents show little explicit logic then means that logical explanation was not commonly practised, and not accepted in the explanation of the facts of life and nature.[58]

That elements of the pantheon and cosmology of mythological tradition, such as the Babylonian creation epic *Enūma Eliš*, appear in the omens of *Enūma Anu Enlil* does not surprise us, but what of the vestiges of such 'lore' in astronomical terminology, preserved even in the mathematical astronomical texts? The description of the appearance of the moon (also the sun and planets) by means of an anthropomorphic personification, such as the grief-stricken moon, certainly reveal theological and mythological elements in the background of celestial divination. Even in strictly astronomical contexts, 'eclipse' may be expressed with the logogram ÍR, the writing for the Akkadian word 'to cry' or, when said of the moon, 'to be eclipsed'. Despite such elements, the omens of *Enūma Anu Enlil* indicate that the celestial phenomena were largely the subject of systematic empirical consideration, usually without overt reference to gods. Whereas the Babylonian cosmogonic myth represents the creation of the cosmos as an allegory involving personified cosmic elements (sea, earth, sky, wind), celestial omens as well as astronomical texts consider and seek to describe the behavior of the phenomena, regardless of their associations with deities. The phenomena of the omen lists are meaningful as physical signs of future, often catastrophic events, but they remain the objects of an inquiry focused on an entirely separate goal, the understanding and even predictive control over the recurrence of those phenomena. As physical signs, therefore, it would seem that despite the occasional personification, or even reference to the moon as 'the god' (*ilu*), the lunar phenomena were of interest *qua* phenomena, not as objects of worship. Apart from the possibility that we cannot understand and therefore will never be able to define how the Babylonians perceived the phenomena, the evidence of the omens presents the coexistence of (to us) contradictory modes of thought about phenomena, for example, that which views the full moon as the moon god wearing a crown, as well

---

56 See Burke (1986), pp. 444–445.

57 Wiggerman (1992).

58 Wiggerman (1992), p. 297.

as that which sees the full lunar disk on the horizon opposite the sun on the fourteenth day of the lunar month. In view of this problem of interpretation, it seems as difficult to categorize Babylonian celestial divination as 'religion' as it does 'science', underscoring the dangers of employing anachronistic terms, as 'religion' and 'science' indeed are in the context of Babylonian civilization.

The classification of omen texts, as well as astronomical texts of all types, with respect to 'religion' as opposed to 'science' suffers from the inapplicability to ancient Mesopotamia of these as separate categories at all. Whereas boundaries may be definable in terms of context or function, the separation of science and religion, much less the conflict between them, finds no support in ancient Near Eastern texts. It seems preferable, as J. H. Brooke has argued, to use 'science' and 'religion' as designations of 'complex social activities involving different expressions of human concern, the same individuals often participating in both'.[59] Clear evidence of participation 'in both' is found in Mesopotamia. In a letter from the celestial divination expert Marduk-šāpik-zēri to king Aššurbanipal, the scribe reviewed for the king the extent of his learning:

> I fully master my father's profession, the discipline of lamentation; I have studied and chanted the Series. I am competent in . . ., 'mouth-washing' and purification of the palace . . . I have examined healthy and sick flesh. I have read the (astrological omen series) *Enūma Anu Enlil* . . . and made astronomical observations. I have read the (anomaly series) *Šumma izbu*, the (physiognomical works) [*Kataduqqû, Alamdi]mmû* and *Nigdimdimmû*, [. . . and the (terrestrial omen series) *Šum]ma ālu*.[60]

If celestial divination and, later, personal astrology belonged within a religious framework, it was in terms of the fact that the agency of the gods was a functional element in the scheme of celestial divination, and presumably horoscopy, and, from a social point of view, late Babylonian astronomy was supported by the institution of the temple.[61] Astronomy functioned without appeal to the gods, although the gods were no less present in the world of Babylonian astronomy. It is clear that the individuals who computed astronomical phenomena were the same as those who copied omen texts and constructed horoscopes. Such an example may be seen in the person of Anu-aba-utēr, a professional 'scribe of *Enūma Anu Enlil*', a title usually rendered as astronomer/astrologer in English. Anu-aba-utēr, from the famous Sin-leqe-unninni family of Uruk, wrote a text now known as ACT 600[62] (written 194 B.C.), which computes first stations of Jupiter according to one of the planetary theories (System A) as well as an astrological text in which lunar eclipse omens, zodiacal signs and associations with cities, temples, stones and plants are systematically related.[63] As

[59] Brooke (1991), p. 42.
[60] Parpola (1993), p. 122.
[61] See Rochberg (1993), pp. 31–45.
[62] Neugebauer (1955), text no. 600.
[63] Weidner (1967), text 2, p. 47.

shown in mathematical astronomical text colophons, this particular scribe held the professional titles *ṭupšar Enūma Anu Enlil*, 'scribe of the omen series *Enūma Anu Enlil*', and *kalû Anu u Antu*, meaning 'lamentation priest of the sky gods Anu and Antu'.[64] His father, Anu-bēl-šunu, while apparently not a *ṭupšar Enūma Anu Enlil*, appears as a tablet owner of many astronomical table texts, and his personal horoscope is extant.[65] Anu-bēl-šunu's horoscope adds to the evidence for the integration of the astronomical and astrological sides of the Babylonian study of heavenly phenomena. This particular horoscope provides a rare example of the computation of solar and lunar positions using degrees and fractions of degrees within zodiacal signs. Another notable feature of Anu-bēl-šunu's horoscope as compared against other examples of the genre is the inclusion of omen apodoses as interpretation of the computed planetary positions.[66] Finally, John Steele has added another tablet to Anu-bēl-šunu's collection, an astronomical text from Uruk containing dates and longitudes of lunar eclipses and many synodic planetary phenomena, which Steele has argued were computed for the purpose of horoscopy.[67]

****

The history of science and the philosophy of science have together exerted a determinative influence on the modern reception and evaluation of Babylonian astronomy. The reconstruction of a linear evolutionary development of science depended upon a certain philosophical position, one in which science, viewed as a distinctive form of knowledge, was seen to have originated in a particular historical context and to have followed a course characterized by progressive growth ever since. Emerging around mid century, however, was the position concerned with whether or not science should be viewed as a distinct form of intellectual belief at all, as well as what criteria should be valid in deciding this issue. The idea, as Joseph Rouse put it, 'that positivism offered a model of science to which no actual science had ever even approximated, and which would be disastrous if prescribed as an ideal',[68] in a sense liberated the history of science. Far from it being useful to raise the question whether evidence for 'theory' is found in Babylonian astronomy in accordance with criteria meant to define the special status of scientific over ordinary thought, the universality of those criteria have themselves been called into question, with historical implications for the validity of their application, both outside and inside modern

64 See Neugebauer (1955), Vol. 1, p. 16.
65 See Beaulieu and Rochberg (1996).
66 See, for example: 'At that time, the sun was in 9 1/2° Capricorn, the moon was in 12° Aquarius: His days will be long' (Lines 3–4).
67 Steele (2000).
68 Rouse (1991), p. 153.

Western contexts.[69] The parallels and accord between 'post-positivist' philosophy of science, with its significantly sociological dimension, and the new historiography of science, with its interest in 'constructivism', may well, as J. R. R. Christie suggested, reflect a post-modern loss of confidence in any 'big picture synthesis', and a tendency toward 'internal differentiation and localization'.[70] It has accordingly not been the objective of this paper to replace Greek with Babylonian science as the new starting point of the old big picture. It was rather to show that the characterization of Babylonian astronomical texts, in accordance with the old historiography, as either 'practical' or 'religious' in an effort to differentiate the Babylonian inquiry from science, and further, to define a Babylonian 'mentality' in terms of its incapacity for 'theory' and 'science', testified to the power of the image of science of that era and had little to do with a consideration of the cuneiform sources themselves.

References

Aaboe, A. (1955–56). On the Babylonian origins of some Hipparchan parameters. *Centaurus*, *4*, 122–125.

Aaboe, A. (2001). *Episodes from the early history of astronomy*. New York, Berlin & Heidelberg: Springer.

Alioto, A. M. (1987). *A history of western science*. Englewood Cliffs, NJ: Prentice-Hall.

Beaulieu, P.-A., & Rochberg, F. (1996). The horoscope of Anu-Bēlšunu. *Journal of Cuneiform Studies*, *48*, 89–94.

Beck, R. (1991). Thus spake not Zarathustra: Zoroastrian pseudepigrapha of the Greco-Roman world. In M. Boyce, & F. Grenet (Eds.), *A history of Zoroastrianism iii* (p. 496). Leiden: Brill.

Brack-Bernsen, L. (1999). Goal-year tablets: Lunar data and predictions. In N. M. Swerdlow (Ed.), *Ancient astronomy and celestial divination* (pp. 172–175). Cambridge, MA, & London: MIT Press.

Britton, J. P. (1993). Scientific astronomy in pre-Seleucid Babylon. In H. D. Galter (Ed.), *Die Rolle der Astronomie in den Kulturen Mesopotamiens* (pp. 61–76). Graz: Beiträge zum 3. Grazer Morgenländischen Symposion.

Brooke, J. H. (1991). *Science and religion: Some historical perspectives*. Cambridge: Cambridge University Press.

Burke, P. (1986). Strengths and weaknesses in the history of mentalities. *History of European ideas*, *7*, 444–445.

Christie, J. R. R. (1993). Aurora, Nemesis and Clio. *British Journal for the History of Science*, *26*, 394.

Comte, A. (1864). *Cours de philosophie positive*, 6 vols. Paris: Bachelier.

Crombie, A. C. (1969). The significance of medieval discussions of scientific method for the scientific revolution. In M. Clagett (Ed.), *Critical problems in the history of science*. Madison, Milwaukee, & London: University of Wisconsin Press.

Cunningham, A., & Williams, P. (1993). De-centring the 'big picture': *The origins of modern science* and the modern origins of science. *British Journal for the History of Science*, *26*, 407–432.

Dampier, W. C. (1946). *A history of science and its relation with philosophy and religion*. New York: Macmillan.

[69] In the panel discussion section concluding the conference proceedings published in McMullin (1988), pp. 223–224, Gary Gutting's statement reflects the awareness of a turning point in attitude among philosophers of science. He said: 'there is a historical and social character to scientific rationality, an assumption that would surely not have been accepted only a short while ago. We have now come to take seriously the historical, and perhaps the social, character of scientific rationality.'

[70] Christie (1993), p. 394. An excellent examination of 'challenges to the classical view of science' may be found in Golinski (1998).

Dolby, R. G. A. (1979). Classification of the sciences: The nineteenth century tradition. In R. F. Ellen, & D. Reason (Eds.), *Classifications in their social context* (pp. 167–193). London, New York, & San Francisco: Academic Press.

Dreyer, J. L. E. (1953). *A history of astronomy from Thales to Kepler*, revised 2nd ed. New York: Dover.

Epping, J. (1881). Zur Entzifferung der astronomischen Tafeln der Chaldäer. *Stimmen aus Maria Laach*, *12*, 277–292.

Epping, J. (1889). *Astronomisches aus Babylon, Stimmen aus Maria Laach Ergänzungsheft* 44. Freiburg im Breisgau: Herder'sche Verlagshandlung.

Feyerabend, P. K. (1981). Problems of empiricism. In P. K. Feyerabend (Ed.), *Philosophical papers* (Vol. 2). Cambridge: Cambridge University Press.

Forbes, R. J., & Dijksterhuis, E. J. (1963). *A history of science and technology: Nature obeyed and conquered*, Vol. 1 *Ancient times to the seventeenth century*. Baltimore, MD: Pelican.

Frankfort, H., Frankfort, H. A., Wilson, J. A., & Jacobsen, T. (1949). *Before philosophy*. Baltimore: Penguin Books.

Giere, R. N. (1988). *Explaining science: A cognitive approach*. Chicago & London: University of Chicago Press.

Goldstein, B. R., & Bowen, A. C. (1991). The introduction of dated observations and precise measurement in Greek astronomy. *Archive for History of Exact Sciences*, *43*, 93–132.

Goldstein, B. R., & Bowen, A. C. (1988). Meton of Athens and astronomy in the late fifth century B.C. In E. Leichty, M. de J. Ellis, & P. Gerardi (Eds.), *A scientific humanist: Studies in memory of Abraham Sachs* (pp. 39–82). Philadelphia: Occasional Publications of the Samuel Noah Kramer Fund, 9.

Goldstein, B. R., & Bowen, A. C. (1983). A new view of early Greek astronomy. *Isis*, *74*, 330–340. Reprinted in M. Shank (Ed.), *The scientific enterprise in Antiquity and the Middle Ages* (pp. 85–95). Chicago & London: University of Chicago Press, 2000.

Golinski, J. (1998). *Making natural knowledge: Constructivism and the history of science*. Cambridge: Cambridge University Press.

Helm, P. R. (1980). *'Greeks' in the neo-Assyrian Levant and 'Assyria' in early Greek writers*. Dissertation, University of Pennsylvania.

Horton, R. (1993). *Patterns of thought in Africa and the West: Essays on magic, religion and science*. Cambridge: Cambridge University Press.

Hunger, H., & Pingree, D. (1999). *Astral sciences in Mesopotamia*. Leiden: Brill.

Hutten, E. H. (1962). *The origins of science*. London: George Allen & Unwin Ltd.

Jones, A. (1999). *Astronomical papyri from Oxyrhynchus: Vols. 1 & 2*. Philadelphia: American Philosophical Society.

Jones, A. (1993). Evidence for Babylonian arithmetical schemes in Greek astronomy. In H. Galter (Ed.), *Die Rolle der Astronomie in den Kulturen Mesopotamiens* (p. 78). Graz: Beiträge zum 3. Grazer Morgenländischen Symposion.

Kingsley, P. (1995). *Ancient philosophy, mystery, and magic: Empedocles and the Pythagorean tradition*. Oxford: Clarendon Press.

Kuhn, D. (1996). Is good thinking scientific thinking? In D. R. Olson, & N. Torrance (Eds.), *Modes of thought: Explorations in culture and cognition* (pp. 261–281). Cambridge: Cambridge University Press.

Lloyd, G. E. R. (1990). *Demystifying mentalities*. Cambridge: Cambridge University Press.

Malinowski, B. (1954). *Magic, science, and religion and other essays*. New York: Anchor Books.

Maul, S. M. (1994). *Zukunftsbewältigung: Eine Untersuchung altorientalischen Denkens anhand der babylonisch-assyrischen Löserituale (Namburbi)*. Mainz am Rhein: Philipp von Zabern.

McMullin, E. (Ed.). (1988). *Construction and constraint: The shaping of scientific rationality*. Notre Dame, IN: University of Notre Dame Press.

Morris, S. P. (1992). *Daidalos and the origins of Greek art*. Princeton, NJ: Princeton University Press.

Neugebauer, O. (1955). *Astronomical cuneiform texts*, 3 vols. London: Lund Humphries.

Neugebauer, O. (1957). *The exact sciences in antiquity*. Providence: Brown University Press.

Neugebauer, O. (1969). *The exact sciences in antiquity*, reprint. New York: Dover Press.

Neugebauer, O. (1975). *A history of ancient mathematical astronomy*, 3 vols. Berlin, Heidelberg & New York: Springer.

Pannekoek, A. (1961). *A history of astronomy*. New York: Dover.
Parpola, S. (1993). *Letters from Assyrian and Babylonian scholars*. Helsinki: Helsinki University Press.
Pedersen, O. (1993). *Early physics and astronomy: A historical introduction*. Cambridge: Cambridge University Press.
Pingree, D. (1973). The Mesopotamian origin of early Indian mathematical astronomy. *Journal of the History of Astronomy*, *4*, 1–12.
Pingree, D. (1981). History of mathematical astronomy in India. In C. C. Gillespie (Ed.), *Dictionary of scientific biography* (Vol. 15, pp. 533–633). New York: Charles Scriber's sons.
Reiner, E. (1995). *Astral magic in Babylonia*. Philadelphia, PA: American Philosophical Society.
Rochberg, F. (1993). The cultural locus of astronomy in late Babylonia. In H. Galter (Ed.), *Die Rolle der Astronomie in den Kulturen Mesopotamiens* (pp. 31–45). Graz: Beiträge zum 3. Grazer Morgenländischen Symposion.
Rochberg, F. (1996). Personifications and metaphors in Babylonian celestial *omina*. *Journal of the American Oriental Society*, *116*, 475–485.
Rochberg, F. (2000). Scribes and scholars: The *ṭupšar Enūma Anu Enlil*. In J. Marzahn & H. Neumann (Eds.), *Assyriologica et Semitica, Festschrift für Joachim Oelsner anläßich seines 65. Geburtstages am 18. Februar 1997* (pp. 359–375). Münster: *Alter Orient und Altes Testament* 252.
Rochberg, F. (in press a). Mesopotamian divination: *Auguria oblativa*. In V. Cappelletti (Ed.), *Storia della scienza*, Vol. I *La Scienza antica*. Rome: Istituto della Enciclopedia Italiana.
Rochberg, F. (in press b). Heaven and earth: Divine–human relations in Mesopotamian celestial divination. In S. Noegel, J. Walker, & B. Wheeler (Eds.), *Prayer, magic, and the stars*. Pennsylvania: Pennsylvania State University Press.
Roberts, J. M. (1996). *History of Europe*. London & New York: Penguin.
Rouse, J. (1991). Philosophy of science and the persistent narratives of modernity. *Studies in History and Philosophy of Science*, *22*, 153.
Salmon, W. C. (1998). *Causality and explanation*. New York & Oxford: Oxford University Press.
Sarton, G. (1952). *A guide to the history of science: A first guide for the study of the history of science with introductory essays on science and tradition*. New York: Ronald Press Company.
Spencer, H. (1874). The genesis of science. In *Essays: Scientific political and speculative*, First Series. London: Williams & Norgate.
Sā'id al-Andalusī (1991). *Science in the medieval world: 'Book of the categories of nations'* (S. I. Salem & A. Kumar, Trans. and Ed.). Austin: University of Texas Press.
Steele, J. M. (2000). A 3405: An unusual astronomical text from Uruk. *Archive for History of Exact Sciences*, *55*, 103–135.
Tannery, P. (1893). *Recherches sur l'histoire de l'astronomie ancienne*. Paris: Gauthier-Villars.
Taylor, F. S. (1963). *A short history of science and scientific thought*, 2nd ed. New York: W.W. Norton & Co. First published 1949.
Toomer, G. (1988). Hipparchus and Babylonian astronomy. In E. Leichty. In M. de J. Ellis, & P. Gerardi (Eds.), *A scientific humanist: Studies in memory of Abraham Sachs* (pp. 353–362). Philadelphia: Occasional Publications of the Samuel Noah Kramer Fund, 9.
Trigger, B. (1989). *A history of archaeological thought*. Cambridge: Cambridge University Press.
Vickery, J. B. (1973). *The literary impact of* The golden bough. Princeton, NJ: Princeton University Press.
van der Waerden, B. L. (1974). *Science awakening II: The birth of astronomy*. Leyden: Noordhoff International Publishing.
Wartofsky, M. (1968). *Conceptual foundations of scientific thought: An introduction to the philosophy of science*. London: Macmillan.
Weidner, E. (1967). *Gestirn-darstellungen auf babylonischen Tontafeln*. Graz: Hermann Böhlaus Nachf.
West, M. L. (1997). *The east face of Helicon: West Asiatic elements in Greek poetry and myth*. Oxford: Clarendon Press.
Whewell, W. (1840). *Philosophy of the inductive sciences*, 2 vols. London: J. W. Parker.
Wiggerman, F. (1992). Mythological foundations of nature. In D. J. W. Meijer (Ed.), *Natural phenomena: Their meaning, depiction and description in the ancient Near East* (pp. 279–306). Amsterdam: Koninklijke Nederlandse Akademie van Wetenschappen Verhandelingen, Afd. Letterkunde, Nieuwe Reeks, deel, 152.