

I

SCIENCE AND ANCIENT MESOPOTAMIA

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How the study of physical phenomena in ancient Mesopotamia relates to the history of science is a question as important for the study of ancient Mesopotamia as it is for the history of science. It addresses both the nature of knowledge in the oldest literate culture as well as the historical reach of what we call science. If the essence of science is to be found in its systematization of knowledge about phenomena and in the various practices associated with such knowledge systems – practices such as celestial observation, prediction, and explanation – then science was a central part of cuneiform intellectual culture.

Divination, magic, and medicine were integral parts of what the scribes termed “scholarship” (*tupsarrūtu*, literally “the art of the scribe”) as well as “wisdom” (*nēmequ*). Scholarship and wisdom were classified as a “secret of the great gods” (*pirišti ilāni rabūti*), referring to a conception of the origins of knowledge with the divine. Cuneiform knowledge was thus reserved for initiates, and injunctions against scribes who were not among the privileged few with access to texts classified as “secret” (*pirištu*) or “guarded” (*niširtu*) are known from the Middle Babylonian (ca. sixteenth to eleventh centuries BCE) to the Late Babylonian (ca. fourth to first centuries BCE) periods.² The classification of knowledge as secret applied to divinatory texts, incantations, apotropaic rituals against ominous signs, medical texts, scholarly commentaries on divinatory texts, and astronomical texts, and by the late first millennium the interrelations among these forms of knowledge become more apparent. A Late Babylonian astronomical text giving rules for calculating month lengths and intervals of lunar visibility around the full moon,

¹ There are various abbreviations that are standard within Assyriology. Those unfamiliar with these may consult http://cdli.ox.ac.uk/wiki/abbreviations_for_assyriology.

² See A. Lenzi, *Secrecy and the Gods: Secret Knowledge in Ancient Mesopotamia and Biblical Israel* (State Archives of Assyria Studies 19; Helsinki: University of Helsinki Press, 2008), pp. 64–6, and cf. P.-A. Beaulieu, “New Light on Secret Knowledge in Late Babylonian Culture,” *ZA* 82 (1992), 98–111.

for example, begins with the statement: “Tablet of the guarded secret of heaven, secret knowledge of the great gods.”³

The sources for cuneiform scholarship span two millennia, beginning in the Old Babylonian Period (ca. 1800–1600 BCE) and continuing until the early centuries of the Common Era. This chapter focuses first on the content of cuneiform scholarship and wisdom, follows with aspects of the methods of the scholar-scribes – observation, prediction, and explanation – particularly with respect to celestial divination and astronomy, and closes with a note on the modern nomenclature and classification of cuneiform astro-nomical/astrological texts.

CUNEIFORM SCHOLARSHIP AND WISDOM

Assyro-Babylonian scholarly divination originated in Babylonia in the second millennium BCE, where collections of texts for the reading of signs, particularly those from the heavens and from the exta of sacrificed sheep, were typically formulated in the casuistic, or case form “If P then Q,” style, as in the following:

If water secretes inside the gall bladder: The flood will come.⁴

If the gall bladder is turned and has wrapped around the “finger”:
The king will seize the enemy country.⁵

The tradition was both systematic and authoritative, and tablet series containing celestial and terrestrial signs (Akkadian *ittātu*) became part of the spread of cuneiform writing to the west of Babylonia during the second millennium, to Emar, Harādum, Alalakh, and Qatna, as well as to the Hittite capital of Hattusas, as important components of an international cuneiform scribal tradition.⁶ Development of scholarly divination in the Middle Babylonian (ca. 1600–1100 BCE) and Middle Assyrian periods (ca. 1400–1050 BCE) indicates the formation at that time of authoritative series, which later, especially in the seventh century BCE, assumed a prominent place in the state libraries of Nineveh, Nimrud, and

³ BM 42282+42294 obv. 1 [tu]ppi niširtu šamê pirištu ilāni rabūti; see L. Brack-Bernsen and H. Hunger, “BM 42282+42294 and the Goal-Year Method,” *SCIAMVS* 9 (2008), 6.

⁴ A. Goetze, *Old Babylonian Omen Texts* (Yale Oriental Series 10; New Haven, CT and London: Yale University Press, 1947), no. 31, col. ii, ll. 38–41.

⁵ *Ibid.*, no. 31, col. ii, ll. 24–30.

⁶ The 13th century BCE Emar omens are found in D. Arnaud, *Recherches au pays d’Astata Emar, vol. 6* (Paris: Recherche sur les civilisations, 1987); Nos. 650–65 are celestial omens. The Har-dum text is published in F. Joannès, “Un Précurseur Paléo-Babylonien de la Série Šumma Ālu,” in H. Gasche, M. Tanret, C. Janssen, and A. Degraeve (eds.), *Cinquante-deux réflexions sur le Proche-Orient ancien offertes en hommage à Léon de Meyer* (Mesopotamian History and Environment, Occasional Publications 2; Leuven: Peeters, 1994), pp.305–12.

Assur.⁷ Cuneiform scribal culture continued in the Babylonia of the Neo-Babylonian, Hellenistic, and Parthian periods, preserving as well as expanding upon the traditional knowledge of omens, rituals, prayers, hemerologies, commentaries, and medical, magical, and astronomical/astrological texts, until the end of cuneiform writing itself.

Compilations of omens in lists represent the result of scholarly systematization and theorization about the meaning of signs, thus establishing in our minds their connection to science. To the divinatory sciences, therefore, belong all the cuneiform scholarly texts formulated in the casuistic manner, which associated a protasis (if-clause) with an apodosis (then-clause) such that a phenomenon was systematically “explained.” Explanation in this context is meant in the sense used by David Pingree when he defined science as “a systematic explanation of perceived or imaginary phenomena or else [it] is based on such an explanation.”⁸ In Pingree’s view, Babylonian divination was “a systematic explanation of phenomena based on the theory that certain of them are signs sent by the gods to warn those expert in their interpretation of future events.”⁹ While this statement only opens up for debate what the nature of explanation is in the divinatory sciences, one way in which divination was explanatory has to do with the relation of an omen apodosis to its protasis and how events were thought to be connected to one another. The establishment of connections, referred to in the texts as divine decisions or judgments, further manifests the Babylonian notion of divine causality and the view of an intimate involvement of the gods in physical phenomena.¹⁰

The divine judgments came in the form of socially relevant events such as attack by enemies, fall of market prices, hunger and want, devastation by flood, pestilence, or plagues of locusts. Fortune or misfortune for the ruling elite (king, prince, lord) was the main concern, as in the following:

If Venus stands behind the Moon: the king will have no rival.

If Venus stands in the Moon’s position: the king’s land will revolt against him.

⁷ In addition to the text series, see the correspondence between scholars and the kings Esarhaddon and Assurbanipal in S. Parpola, *Letters from Assyrian Scholars to the Kings Esarhaddon and Assurbanipal*, 2 vols. (Neukirchen-Vluyn: Butzon and Bercker Kevelaer, 1970–83), vol. 1: *Texts*; vol. 2: *Commentary and Appendices*; H. Hunger, *Astrological Reports to Assyrian Kings* (State Archives of Assyria (= SAA) 8; Helsinki: University of Helsinki Press, 1992); and S. Parpola, *Letters from Assyrian and Babylonian Scholars* (State Archives of Assyria (= SAA) 10; Helsinki: University of Helsinki Press, 1993).

⁸ D. Pingree, “Hellenophilia Versus the History of Science,” *Isis* 83 (1992), 554–63, quotes from 559–60.

⁹ *Ibid.*

¹⁰ F. Rochberg, *In the Path of the Moon: Babylonian Celestial Divination and Its Legacy* (Leiden and Boston, MA: Brill, 2010), pp. 411–24.

If Venus reaches the Moon and enters into the Moon: the king's son will seize his father's throne.¹¹

Such public apodoses were generally found in celestial divination, malformed birth omens (of the series *Šumma izbu*), and extispicy. Other omen series (as in the physiognomic omens of *Alamdimmū* or the birth omens of *Iqqur īpuš*) focused on the stability of a man's household, personal health, wealth, happiness, and lifespan. Private apodoses would later be integrated within natal astrological omens and horoscopes.¹²

As most clearly represented in the surviving texts of the library at Nineveh, the corpora of five distinct scholarly professions represent the scholars' repertoire of knowledge, namely, those of the "scribe of *Enūma Anu Enlil*" (*tupšar Enūma Anu Enlil*), who was expert in astral phenomena, the "one who inspects (the liver and exta)" (*bārū*), i.e., the diviner expert in extispicy; the "exorcist" (*āšīpu*), who treated human beings afflicted by divine disfavor via incantations and rituals aimed at re-establishment of the right relationship between human and divine; the "physician" (*asū*), who treated the body in the grip of demonic or divine influence (what we call disease); and the "lamentation priest" (*kalū*), who was responsible for religious ritual performance (songs of lamentation, also the playing of the kettledrum for the ritual against the evil of a lunar eclipse).¹³ Rigid distinctions did not obtain between these scribal professions and the texts they wrote, copied, and utilized. Omens (including astral, abnormal birth, and human physiognomic) and astronomical texts are, for example, within the professional domain of *āšīpus* and *kalūs*.

Astral omens begin to appear in the Old Babylonian period with particular attention to lunar eclipses. Eventually the canonical *Enūma Anu Enlil* encompassed a range of phenomena of the moon, sun, planets, fixed stars, and weather. Of particular though not exclusive interest to the scholars were periodic phenomena, and the understanding of astronomical periodicities was therefore increasingly of importance. The letters to the Assyrian kings Esarhaddon and Assurbanipal in the seventh century reflect some ability to predict astronomical phenomena such as planetary appearances and even lunar eclipses, at least in the short term. Also attested in the seventh century, in a tablet that gives celestial omens in a numerical cryptography, are periods

¹¹ E. Reiner and D. Pingree, *Babylonian Planetary Omens, Part 3* (Groningen: Styx, 1998), p. 45, lines 38–9 and 46.

¹² F. Rochberg, *The Heavenly Writing: Divination, Horoscopy, and Astronomy in Mesopotamian Culture* (Cambridge: Cambridge University Press, 2004), pp. 202–6, and passim. See also F. Rochberg, *Babylonian Horoscopes* (Transactions of the American Philosophical Society 88; Philadelphia, PA: American Philosophical Society, 1998).

¹³ P.-A. Beaulieu and J. P. Britton, "Rituals for an Eclipse Possibility in the 8th Year of Cyrus," *Journal of Cuneiform Studies* (henceforth "JCS") 46 (1994), 73–86; D. Brown and M. Linssen, "BM 134701 = 1965–10–14,1 and the Hellenistic Period Eclipse Ritual from Uruk," *RA* 91 (1997), 147–66; and M. Linssen, *The Cults of Uruk and Babylon: The Temple Ritual Texts as Evidence for Hellenistic Cult Practice* (Leiden and Boston, MA: Brill, 2004), pp. 306–20.

for the planetary synodic cycles, some consistent with later so-called goal-year periods (see, pp. 20 and 24, below).¹⁴ Prediction of lunar and planetary phenomena utilizing the parameters of so-called goal-year periods is also attested in the sixth-century Strassmaier Cambyses 400.¹⁵ By the fifth century and later, the small group of cuneiform horoscopes (or proto-horoscopes¹⁶) required the calculation of planetary positions, and these could either be made with goal-year methods, or perhaps by means of interpolations from the mathematical schemes characteristic of the ephemerides of Seleucid Babylonia.¹⁷ Predictions for astral phenomena did not diminish the ominous significance of signs. The response to an occurrence of a lunar eclipse, even in the Seleucid period (after 300 BCE) when prediction of eclipses is well attested, was the performance of an apotropaic ritual to dispel its evil.¹⁸

Other celestial omens are not from periodic phenomena, such as the following planetary omens (note that square brackets indicate breaks in the clay tablet where the text is restored by duplicates):

[If Venus at her appearance is red: (abundance for the people)], the harvest of the land will succeed, the king of Akkad will experience [joy] – the east wind blows.

If Venus at her appearance is black: Enlil will glare angrily [at the land], in the land business will be poor [. . .], the south wind blows.

[If Venus at her appearance is white:] There will be drought in the land, [. . .] – the north wind blows.¹⁹

In addition to celestial and terrestrial omens, medical texts systematized both symptoms and therapeutic techniques for reference purposes.²⁰ Because the aetiology of disease was considered divine, demonic, from ghosts (*qāt eṭemmi* “hand of a ghost”), witches (*kišpu* “witchcraft”), curses (*mamītu*), or anything evil (*mimma lemnu* “whatever is evil”), the *āšīpu* (“exorcist”) specialized in the incantations and liturgy used to appeal to deities who had the

¹⁴ See C. J. Gadd, “Omens Expressed in Numbers,” *JCS* 21 (1967), 52–63, especially p. 61. The periods in question are Saturn 59, Venus 8, Mars 15, and Jupiter 12. See J. P. Britton, “Studies in Babylonian Lunar Theory Part II. Treatments of Lunar Anomaly,” *Archive for History of Exact Sciences* 63 (2009), 357–431, especially p. 349.

¹⁵ J. P. Britton, “Remarks on Strassmaier Cambyses 400,” in M. Ross (ed.), *From the Banks of the Euphrates: Studies in Honor of Alice Louise Sloisky* (Winona Lake, IN: Eisenbrauns, 2008), pp. 7–33, with bibliography.

¹⁶ H. Hunger and D. Pingree, *Astral Sciences in Mesopotamia* (Handbuch der Orientalistik; Leiden, Boston, MA, and Cologne: Brill, 1999), pp. 26–7.

¹⁷ Rochberg, *Babylonian Horoscopes*, pp. 7–11.

¹⁸ See note 12.

¹⁹ Reiner and Pingree, *Babylonian Planetary Omens*, Part 3, pp. 40–3, Group A, VAT 10218 lines 13–15.

²⁰ I. L. Finkel, “On Late Babylonian Medical Training,” in A. R. George and I. L. Finkel (eds.), *Wisdom, God and Literature: Studies in Assyriology in Honor of W. G. Lambert* (Winona Lake, IN: Eisenbrauns, 2000), pp. 137–224; M. J. Geller, *Ancient Babylonian Medicine: Theory and Practice* (Oxford: Wiley-Blackwell, 2010).

power to heal and protect the patient. Incantations could be used in combination with other prophylactic and apotropaic acts such as fumigation, the topical application of salves, and the use of amulets as means to appease the divine sources of illness and pain. Incantations were collected, standardized up to a point, and had a kind of canonical force in the same way as did divinatory texts.²¹

While divinatory texts began with discrete genre boundaries (celestial, physiognomic, birth, etc.), in the last half of the first millennium, during Persian (Achaemenid), Hellenistic (Seleucid) and Parthian (Arsacid) Babylonia, interrelations are increasingly integrated, and Late Babylonian scholarly commentaries establish more direct connections between celestial and terrestrial realms. The integration of astral with terrestrial divinatory sciences seems to have been made possible by the development of astrology, that is, by the application of celestial signs for the human being (and the human body) in general, no longer focusing, as did *Enūma Anu Enlil*, only on the king. In one commented text, for example, omen series concerning human appearance, health, and births were brought into relation with celestial signs. Its opening lines:

(The omen series) “If a Malformed fetus,” (the omen series) “Symptoms,” (the omen series) “Physical Characteristics.” Aries, Taurus, Orion are for predicting the appearance. When they (the planets?) “reach” (the various zodiacal signs) it refers to physical characteristics. Observe the secret of heaven and earth!²²

The laconic nature of the commentary leaves open the question of exactly what the connections between birth, medical, physiognomic, and astrological phenomena were, yet a decidedly astrological, that is genethliological (birth astrology), turn has been taken. An important feature of later astronomical texts (Diaries and Almanacs) was to track when the planets “reached” each zodiacal sign. The colophons of Almanacs state that these texts are “measurements of the ‘reachings’ of the (divine) planets” (*mešhi ša kašādī ša ^dbibbī*). The arrival of a planet into a sign was presumably astrologically significant, though the statements of these “reachings” in astronomical texts do not provide an astrological meaning. These same astronomical texts, namely the Almanacs and Diaries, were very likely

²¹ For example, the series *Šurpu* (see E. Reiner, *Šurpu: A Collection of Sumerian and Akkadian Incantations* (AfO Beiheft 11; Graz: Archiv der Orientforschung, 1958)); the anti-demon text *Udug-hul* (see M. Geller, *Forerunners to Udug-Hul: Sumerian Exorcistic Incantations* (Wiesbaden: F. Steiner Verlag, 1985)); the ritual series *Mušš’u* (see B. Böck, “‘When You Perform the Ritual of Rubbing’: On Medicine and Magic in Ancient Mesopotamia,” *Journal of Near Eastern Studies* 62 (2003), 1–16, with further bibliography).

²² See B. Böck, “‘An Esoteric Babylonian Commentary’ Revisited,” *Journal of the American Oriental Society* 120 (2000), 615–20.

used as sources for the zodiacal positions of the planets quoted in cuneiform horoscopes.²³

Astrology finds a connection to extispicy in the Late Babylonian Period as well, when traditionally ominous parts of the liver are associated with a god, one of the twelve months, and a heliacally rising star, thus: “the Path (of the liver) is Šamaš, Ajāru, Taurus; the gall bladder is Anu, Tašrītu, Libra,” and so on.²⁴ Magical practice also established new connections to the zodiac, such as in a list of spells with their correlated regions in the zodiacal signs.²⁵ Even the term “sign” or “ominous part” (literally “flesh” UZU = *šīru*) found earlier in liver omens occurs again in a Seleucid astrological context where dodekatemoria (1/12ths) of zodiacal signs are referred to as 12 UZU.MEŠ HA.LA ša ^{múl}LÚ.HUN.GÁ (variant, ^{múl}LU) “the 12 signs (ominous parts) of the zodiacal sign Aries.”²⁶

Astronomy and the preservation by the *ummānu* of esoteric learning in magical, medical, and liturgical texts dominated the activities of the Late Babylonian literati in the last centuries of the cuneiform tradition. Testimony to the continuation of the practice of Babylonian astronomy in the first century CE comes from the Elder Pliny (23–79 CE), who claims to have seen the astronomers in Babylon in the “Temple of Jupiter-Bēl.”²⁷ On the surface, the astronomical contents of the quantitative predictive texts of the Late Babylonian Period do not appear to relate to divinatory knowledge, yet the texts that predict such events as rains and floods, enemy attacks, and market prices, as well as the few preserved colophons on ephemerides, all reflect the fact of the identification of the astronomers as members of the classes of *ṭupšar Enūma Anu Enlil*, *kalū*, and *āšīpu*. Furthermore, a few preserved rubrics indicate that these tablets were classified by the scribes, along with other texts of *ṭupšarrūtu*, as “secret” (*pirīštu*), as in the following colophon from a text dated to the second century BCE:

On eclipses of the moon.

Tablet of Anu-bēl-šunu, lamentation priest of Anu, son of Nidintu-Anu, descendant of Sin-lēqi-unninni of Uruk. Hand of Anu-[aba-utēr, his son, scri]be of *Enūma Anu Enlil* of Uruk. Uruk, month I, year 12[1?] Antiochus [. . .]

²³ F. Rochberg, “Babylonian Horoscopy: The Texts and Their Relations,” in N. M. Swerdlow (ed.), *Ancient Astronomy and Celestial Divination* (Cambridge, MA: MIT Press, 1999), pp. 39–60, and see also Rochberg, *Heavenly Writing*, pp. 145–57.

²⁴ SpTU 14, 159; see U. Koch-Westenholz, *Babylonian Liver Omens: The Chapters Manzāzu, Padānu, Pān tākalti of the Babylonian Extispicy Series Mainly from Assurbanipal’s Library* (The Carsten Niebuhr Institute of Near Eastern Studies Publications, 25; Copenhagen: Museum Tusulanum Press, 2000), pp. 24–5.

²⁵ BRM 4 20, with BRM 4 19 (and parallels with STT 300 although without the zodiacal references), see M. J. Geller, *Melothesia in Babylonia: Medicine, Magic, and Astrology in the Ancient Near East* (Science, Technology, and Medicine in Ancient Cultures 2; Berlin: De Gruyter, 2014), pp. 28–57.

²⁶ TCL 6 14:11, 12, 13, and 20; see A. J. Sachs, “Babylonian Horoscopes,” *JCS* 6 (1952), 49–75, p. 66.

²⁷ Pliny, *The Natural History* VI 123, VII 193.

Whoever reveres Anu and Antu [. . .]

Computational table. The wisdom of Anu-ship, exclusive knowledge of the god [. . .]

Secret knowledge of the masters. The one who knows may show (it) to an[other one who knows]. One who does not know may not [see it. It belongs to the forbidden things] of Anu, Enlil [and Ea, the great gods].²⁸

CELESTIAL OBSERVATION²⁹

Astronomical texts do not appear prior to the Old Babylonian period (2000–1600 BCE). No astronomical texts are known in the Sumerian language; however, some rudimentary recognition of observed astronomical phenomena is attested in the early third millennium BCE (Uruk level IV) in an Uruk cultic text concerning offerings to the goddess Inanna as the morning and evening star. A cult to the astral Inanna continued in Sumerian city-states through the third millennium. Otherwise, poetic descriptions, such as of the moon god and his many “cattle,” i.e., the stars, are found in Sumerian literature,³⁰ and lists of star names are found in Sumerian lexical texts of the Old Babylonian period (*Ura 5*, together with geographical names³¹), roughly contemporaneous with the earliest evidence for systematic attention to the celestial bodies as signs.

One of the modern debates about the role of observation in the cuneiform tradition has to do with the origins of omen divination, namely whether the observation of co-occurrences of phenomena led to the idea that one phenomenon (P) could indicate another (Q).³² The evidence is clear that signs were studied for their appearances, regularities, and irregularities, and the patterns of their occurrence. No evidence for an observational connection of signs to portents, however, can be demonstrated. A variety of non-observational principles can

²⁸ O. Neugebauer, *Astronomical Cuneiform Texts*, 3 vols. (London: Lund Humphries, 1955), No. 135, reading of the date is uncertain, see p. 19 for discussion; also H. Hunger, *Babylonische und Assyrische Kolophone* (Alter Orient und Altes Testament 2; Kevelaer: Butzon & Bercker; Neukirchen-Vluyn: Neukirchener Verlag des Erziehungsvereins, 1968), No. 98.

²⁹ See also F. Rochberg, “Scientific Observation and Knowledge of the World in Cuneiform Culture” in E. Robson and K. Radner (eds.), *Oxford Companion to Cuneiform Culture* (Oxford: Oxford University Press), pp. 618–36.

³⁰ See F. Rochberg, “Sheep and Cattle, Cows and Calves: The Sumero-Akkadian Astral Gods as Livestock,” in S. Melville and A. Slotsky (eds.), *Opening the Tablet Box: Near Eastern Studies in Honor of Benjamin R. Foster* (Culture and History of the Ancient Near East, 42; Leiden and Boston, MA: Brill, 2010), pp. 347–59.

³¹ See <http://oracc.museum.upenn.edu/dcclt/Q000042>, lines 387–410.

³² For example, P. Huber, “Dating by Lunar Eclipse Omens with Speculations on the Birth of Omen Astrology,” in J. L. Berggren and B. R. Goldstein (eds.), *From Ancient Omens to Statistical Mechanics: Essays on the Exact Sciences Presented to Asger Aaboe* (Copenhagen: University Library, 1987), pp. 3–13.

be identified in the texts to explain how a sign was correlated with a portent.³³

As seen in the examples quoted above, one such principle was analogy. The water inside the gall bladder signifies the flood. The gall bladder wrapped around the “finger” (identified with the band of tissue called the *processus caudatus*, or possibly the *processus pyramidalis*) was read as a visual analogue for the king’s taking of an enemy. Not every omen exhibits such analogic reasoning from protasis to apodosis, but in many cases an association by homophony or synonymy will explain the connection between protasis and apodosis. Whatever observational dimension is to be found in the divinatory sciences is restricted to the observation of the signs themselves, not to the form of reasoning known as “after this, therefore because of this” (*post hoc ergo propter hoc*). Observation itself is an important part of why the omen texts have been classified as “scientific” in modern scholarship, and legitimately so, as the observation of physical phenomena was foundational to the development of knowledge about their intrinsic properties and behavior.

A systematic accounting of seasonal astronomical phenomena is first attested in a Middle Assyrian Period compendium entitled MUL.APIN “Plow Star.”³⁴ Included are lists of stars; lists of periods of visibility for the five naked-eye planets; periods of invisibility for the planets Venus, Jupiter, Mars, and Saturn; intercalation schemes to reconcile the solar year with the lunar month; equinoxes and solstices; the variation in length of daylight; and omens (not identical to those of *Enūma Anu Enlil*). The interest in the planets is in the seasonal recurrence of heliacal risings and settings, phenomena that were taken to be signs, as is clear from *Enūma Anu Enlil* Tablet 63, discussed below, p. 19. Of six star-lists in MUL.APIN, two reflect an interest in the seasonal reappearance of stars or constellations. These lists give schematic dates (on the 1st, 5th, 10th, 20th, and 25th of an ideal month, that is, one of twelve thirty-day months) for the heliacal risings of thirty-five stars (constellations) and the associated intervals between their risings.³⁵ While not explicitly divinatory, MUL.APIN includes some omens. Its astronomical content, however, is consistent with that of *Enūma Anu Enlil*, and it devotes one of its star lists to the associations between stars and gods. MUL.APIN provides a representation of the state of astronomical knowledge of the end of the second millennium BCE.

The phenomena compiled in the Old Babylonian forerunners to *Enūma Anu Enlil*, MUL.APIN, and the Astrolabes are based presumably on

³³ J.-J. Glassner, “Pour un lexique des termes et figures analogiques en usage dans la divination mésopotamienne,” *Journal asiatique* 272 (1984), 15–46, and Rochberg, *In the Path of the Moon*, pp. 399–409, especially pp. 400–4.

³⁴ See H. Hunger and D. Pingree, *MUL.APIN: An Astronomical Compendium in Cuneiform* (Archiv für Orientforschung Beiheft 24; Horn: Verlag Ferdinand Berger & Söhne, 1989).

³⁵ Further discussion is found in Hunger and Pingree, *Astral Sciences*, pp. 57–73.

longstanding knowledge derived from naked-eye astronomy, though in no way do these represent contemporary observational texts. In celestial omens there is a sense in which the phenomena considered ominous were expected to “appear” or be “observed,” as is clear from the frequent use of these verbs in the protases of celestial omens. However, the ominous astral phenomena written in the protases of omen texts cannot be taken to represent datable observations of phenomena. True observations of astral phenomena are found in two groups of texts. The first, in which the phenomena are clearly to be interpreted as omens, is a group of Neo-Assyrian scholarly texts from the reigns of Esarhaddon (680–669 BCE) and Assurbanipal (668–627 BCE), now termed “Reports.”³⁶ The second, where the relationship to omens is less clear, is the archive compiled in the city of Babylon from the eighth century BCE (only extant from the seventh century) to the first century BCE, now termed “Diaries.”³⁷

Concern about visibility of ominous phenomena is revealed in the following Report:

Twice or thrice we watched for Mars today (but) we did not see (it); it has set. Maybe the king my lord will say as follows: “is there any (ominous) sign in (the fact) that it set?” (I answer): “There is not.”³⁸

Or:

Concerning Mercury, about which the king my lord wrote to me: yesterday Issar-šumu-ereš had an argument with Nabû-ahhe-eriba in the palace. Later, at night, they went and all made observations; they saw (it) and were satisfied.³⁹

The Reports are clearly concerned with the meaning of the phenomena as signs, and evaluation of relevant omens are given in the Reports by means of citations from *Enūma Anu Enlil*. Within the period covered by the Reports, mostly during the first half of the seventh century, and from cities such as Assur, Babylon, Nippur, Uruk, Dilbat, Cutha, and Borsippa, the Reports were written very soon after the observations were made and transported to Nineveh, and in some cases ritual apotropaic measures were taken to avoid bad portents. The observations were made for the purpose of determining portents, but some ominous phenomena that were known to be periodic were by then already the objects of numerical schematization.⁴⁰

³⁶ Hunger, *Astrological Reports*.

³⁷ H. Hunger and A. J. Sachs, *Astronomical Diaries and Related Texts from Babylonia*, 6 vols. (Vienna: Österreichische Akademie der Wissenschaften, 1988–2006).

³⁸ Hunger, *Astrological Reports*, 7: 5–rev.4.

³⁹ *Ibid.*, 83:4–rev.3.

⁴⁰ See the discussion of ideal planetary schemes in D. Brown, *Mesopotamian Planetary Astronomy–Astrology* (Cuneiform Monographs, 18; Groningen: Styx, 2000), pp. 113–22.

The duration of the moon's visibility at night is a good example, as seen in *Enūma Anu Enlil* Tablet 14 (discussed below, pp. 19–20).⁴¹

In the Diaries, the combination of astronomical data about the moon and the planets with political and economic events is somewhat reminiscent of *Enūma Anu Enlil*. A text will combine a nightly record of the positions of the planets with respect to a certain set of ecliptical stars (Normal Stars), eclipses, synodic appearances of the planets, and information as to the prices of barley, wool, mustard, and sesame. Additionally, the level of the Euphrates River will be reported, as well as the zodiacal signs in which each planet is found at the end of the month. Other notable events are included, such as cultic or military activities affecting the king. The following Diary reports on the routing of Darius III's army by Alexander the Great at Gaugamela in the Diary for –330:

On the morning of the twenty-fourth of the month of Ulūlu, the king of the world [Alexander] raised his standard [lacuna]. The armies engaged each other and the king's soldiers suffered a heavy defeat. The troops abandoned their king [Darius] and headed back to their cities. They fled to the lands in the east.⁴²

Finally, for the pre-Seleucid period, seventh-century tablets with observations of the synodic phenomena of the planets are sparsely attested, one from years 2 to 10 of Šamaš-šumu-ukīn and one from years 1 to 14 of Kandalanu, of first and last visibilities of Mars and of Saturn respectively.⁴³ Another Saturn observation text from sixth-century Uruk includes first and second stations to the first and last visibilities during the period from year 28 to 31 of Nebuchadnezzar II.⁴⁴ During this period, on the basis of the few extant planetary observation texts, the practice of citing planets with respect to a certain set of Normal Stars and the use of cubits, fingers, and degrees (UŠ) was still in the process of standardization.⁴⁵

Typical of cuneiform scholarly texts is the long lacuna between the seventh-century copies of MUL.APIN and the next group of extant astronomical sources, from the fourth century and later. As is the case in the interim period between the abundance of Neo-Assyrian texts relating to astronomy and celestial divination and the bulk of extant texts from the

⁴¹ The edition is in A. George and F. N. H. Al-Rawi, "Enuma Anu Enlil XIV and Other Early Astronomical Tables," *Archiv für Orientforschung*, 38–39 (1991), 52–73.

⁴² Hunger and Sachs, *Astronomical Diaries and Related Texts*, vol. 1, No. –330: 14'–18', translation from http://www.livius.org/aj-al/alexander/alexander_27.html.

⁴³ Hunger and Pingree, *Astral Sciences*, pp. 173–4.

⁴⁴ H. Hunger, "Saturnbeobachtungen aus der Zeit Nebukadnezars II," in Joachim Marzahn and Hans Neumann (eds.), *Assyriologica et Semitica: Festschrift für Joachim Oelsner* (Münster: Ugarit Verlag, 2000), pp. 189–92.

⁴⁵ A. Jones, "A Study of Babylonian Observations of Planets Near Normal Stars," *Archive for History of Exact Sciences* 58 (2004), 530–34. See also J. M. Steele, "Celestial Measurement in Babylonian Astronomy," *Annals of Science* 64 (2007), 293–325.

Diaries archive from Babylon (only one survives from the seventh century, one from the sixth century, and four from the fifth century) and astronomical table texts from Babylon and Uruk, the state of astronomical knowledge before the Hellenistic period must be inferred from the evidence of relatively few texts. One such is the tablet known as “Strassmaier Cambyses 400,” after its original publication from 1890.⁴⁶ This tablet contains astronomical data for the year 523 BCE, or year 7 of Cambyses the Achaemenid ruler. The contents show that already from the early sixth century BCE, Babylonian astronomers had been making and no doubt recording observations of the Lunar Six⁴⁷ and of planetary synodic phenomena, and had also begun calculating the latter phenomena on the basis of goal-year periods. Confirmation of the early, i.e., seventh-century, collection of Lunar Sixes is found in tablets devoted solely to these data.⁴⁸ Interestingly, among these sources is one from Nippur, possibly for the year 618 BCE.⁴⁹ What is clear is that observation and prediction developed hand-in-hand, with prediction by calculation and measurement supplying data not accessible due to weather or other visibility conditions.

PREDICTION AND CALCULATION

Early identification of periodic phenomena such as the duration of the moon’s visibility at night and the variation in the length of daylight throughout the year gave rise to quantitative methods for predicting these phenomena based on linear mathematical models. Ultimately, eclipses, equinoxes and solstices, the synodic appearances of the planets, and the date of first visibility of the moon were also predicted by means of similar, though more complex models involving relations between variables, functions to account for their variation, and excellent numerical parameters.

Astronomy as the study of the periodic behavior of astral phenomena and the development of mathematical models for their prediction seem to have arisen together with the attention to the phenomena as signs. Among the earliest examples are the “Venus Tablet of Ammišaduqa” (= *Enūma Anu*

⁴⁶ J. Strassmaier, *Inschriften von Cambyses* (Babylonische Texte 9; Leipzig: Eduard Pfeiffer, 1890), No. 400; Britton, “Remarks on Strassmaier Cambyses 400.”

⁴⁷ The Lunar Six phenomena are: at the beginning of the month in the evening, NA is the time interval between sunset and moonset on the evening of the first lunar visibility after conjunction of sun and moon; in the middle of the month, ŠÚ is the interval from moonset to sunrise when the moon set for the last time before sunrise; in the middle of the month, na is the interval between sunrise and moonset when the moon set for the first time after sunrise; ME the interval between moonrise to sunset when the moon rose the last time before sunset; GE₆ the interval between sunset and moonrise when the moon rose the first time after sunset; at the end of the month, in the morning KUR is the interval between moonrise and sunrise when the moon was visible for the last time before conjunction.

⁴⁸ P. J. Huber and J. M. Steele, “Babylonian Lunar Six Tablets,” *SCIAMVS* 8 (2007), 3–36.

⁴⁹ *Ibid.*, pp. 15–16, Text B (N.2349).

Enlil Tablet 63) and the lunar visibility tablet *Enūma Anu Enlil* Tablet 14. In addition to its importance for reconstructing the series *Enūma Anu Enlil*, the Venus Tablet continues to play a role in modern astronomical chronology for the ancient Near East.⁵⁰ The text, or a part of it, was thought to be based on a source from the reign of King Ammišaduqa of Babylon in the mid-seventeenth century BCE, in which the appearances and disappearances of the planet would have been directly observed and recorded (the alleged text is no longer extant). Surviving exemplars, all written during the Neo-Assyrian period or later, demonstrate an awareness that 5 synodic cycles of the appearances of Venus (as evening and morning star, that is, morning rise and set and evening rise and set) occur every 8 years (that is, every 99 Babylonian months minus 4 days). The following is the first line:

(Year 1) If on the 15th of Month XI (*Šabatu*) Venus disappeared in the West (Evening Last), remained invisible 3 days, and reappeared in the East on the 18th day of Month XI: Catastrophes of kings; Adad will bring rains, Ea will bring floods, one king will send greetings to another king.⁵¹

The omens of *Enūma Anu Enlil* Tablet 63 are constructed from a sequence of synodic phenomena of Venus over a period of 21 years (the length of the reign of Ammišaduqa) formulated as conditional statements “If Venus . . .,” together with associated events “then . . .” In its extant form, however, the tablet does not preserve a list of Venus observations from the Old Babylonian period, but is a composite text, and includes some computed values for the phenomena and the periods of invisibility that themselves have been copied and corrupted in the manuscript transmission.

The other tablet from *Enūma Anu Enlil* that represents the use of an arithmetic model for the description of an astronomical phenomenon is Tablet 14.⁵² It provides a linear zigzag scheme for the length of visibility of the moon each night for the 30 days of the two equinoctial months (when day and night are of equal length as the sun crosses the equator). The interest in duration of lunar visibility is tied to the ominous nature of the moon when visible. The lunar visibility scheme is based on an ideal year of 360 days and a ratio of longest to shortest daylight of 2:1, also a schematic consequence of the mathematical model.

The use of the sexagesimal number notation as well as agreeable sexagesimal numbers (12, 30, 360) is typical of these early astronomical texts.

⁵⁰ T. de Jong, “Astronomical Fine-Tuning of the Chronology of the Hammurabi Age,” *Journal Ex Oriente Lux* 44 (2012–13), 147–67.

⁵¹ E. Reiner and D. Pingree, *Babylonian Planetary Omens, Part 1: Enūma Anu Enlil Tablet 63: The Venus Tablet of Ammišaduqa* (Malibu, CA: Undena Publications, 1975), p. 29.

⁵² See Hunger and Pingree, *Astral Sciences*, pp. 44–50.

Babylonian sexagesimal place value notation entered the stream of the Western scientific astronomical tradition, where it continues in the modern practice of measuring degrees of time and arc. Related to the lunar visibility scheme is another zigzag scheme for the duration of daylight throughout the year, attested in the so-called “Astrolabe” or “Three Stars Each,” which assigned heliacal risings of prominent stars to the twelve thirty-day months of the ideal year, as well as the astronomical compendium MUL.APIN.⁵³ In the Astrolabe (and in *Enūma Anu Enlil* Tablet 14), daylight (and lunar visibility) increases and decreases by a constant between two extrema. The phenomena are thereby modeled schematically with a minimum of observational input, probably principally that, at the equinoxes, day and night are each one-half of an entire day, i.e., 3,0 UŠ (time degrees, hence 180 degrees, or 12 hours of an equinoctial day).

David Brown suggested that the ideal schemes were suited to divinatory purposes as they sufficed to indicate whether phenomena were timely or not (expressed as *ina la minātišu* “not in accordance with its normal number,” or *ina la simanišu* “not at its proper time”), and therefore interpretable as of favorable or unfavorable portent.⁵⁴ The early astronomical models attest to the interdependence of observational and schematic components, a relationship that lies at the very core of the connection between observation and theory in science generally.

The period between the Neo-Babylonian Empire and the arrival of Alexander the Great (i.e., between ca. 626 and 331 BCE) was a creative one for predictive astronomy in Babylonia. Texts from this intermediate stage can be characterized by a progressive utilization of period relations in the prediction of lunar as well as planetary phenomena. By the Seleucid period, goal-year methods were regularly in use, and the astronomical records, now termed “Goal-Year Texts,” were prepared by means of compiling lunar and planetary observations from the Diaries the requisite number of years for one period before the goal year. Thus a Goal-Year Text presents the raw data for predicting the future occurrences of the dates and zodiacal signs for the synodic phenomena of Jupiter, Venus, Mercury, Saturn, and Mars (in that order), and the moon, giving data for the Lunar Sixes as well as eclipses. According to the rubric given to these texts by the scribes, they included data for “the 1st day, appearances, passings, and eclipses which have been established for the year x.”⁵⁵ Goal-year predictions were then introduced into Diaries when weather prevented observation, as well as into Almanacs and Normal Star Almanacs.⁵⁶

⁵³ See Hunger and Pingree, *Astral Sciences*, pp. 50–7.

⁵⁴ Brown, *Mesopotamian Planetary Astronomy-Astrology*, p. 106.

⁵⁵ A. J. Sachs, “A Classification of Babylonian Astronomical Tablets of the Seleucid Period,” *Journal of Cuneiform Studies* 2 (1948), 271–90, pp. 284–5.

⁵⁶ L. Hollywood and J. M. Steele, “Acronycal Risings in Babylonian Astronomy,” *Centaurus* 46 (2004), 145–62, pp. 154–5.

Predictive models, making use of mathematical schemes using either a periodic zigzag function or a periodic step function came to full maturation in Seleucid Babylonia.⁵⁷ These are tabulations of the dates, positions, and values instrumental for their calculation. Such tables depended upon the use of the fixed intercalation scheme of the nineteen-year cycle and the Seleucid Era (312 BCE), as well as the establishment, around 400 BCE, of the fixed zodiac of twelve thirty-degree signs.⁵⁸ Evidence for the astrological application of such calculated astronomical data is clear in Late Babylonian natal omens that forecast the fortunes of an individual on the basis of planetary synodic phenomena.⁵⁹ But Late Babylonian omen astrology was not limited to genethliological concerns, as the subjects traditionally of importance to celestial divination (enemy attacks,⁶⁰ rise and fall of the market, rains and floods, etc.) are also well attested in omens composed later than and clearly building on the content of *Enūma Anu Enlil*.⁶¹ Specific mention of the periodicity of such terrestrial occurrences shows that the predictive science of astronomy was carried out in concert with an effort to know the periodicities of future occurrences of events of concern to human beings, such as enemy attacks, fall of the economy, ruination of the harvest, and so on:

[. . .] Pay attention to [. . .], the appearance and last visibility of Venus and Mercury and [. . .] which on the wrong day is not . . . an omen. (If) the rain begins [. . .] from the 1st day to the 15th day and remains: its rain is not good. At the end of the year it is good . . . There will be as many storms now as there were storms in the past. You will predict a swollen flood. [. . .] waters will flow from breaches (in the dykes). (If) a planet appears and (there is) rain and flood: now (there will be) rain and flood.⁶²

⁵⁷ For a full exposition of the mathematical methods of Systems A and B, see Neugebauer, *Astronomical Cuneiform Texts* and Otto Neugebauer, *A History of Ancient Mathematical Astronomy* 3 vols. (Berlin and New York: Springer Verlag, 1975). See also the chapter by Steele, in this volume.

⁵⁸ See J. P. Britton, "Studies in Babylonian Lunar Theory: Part III. The Introduction of the Uniform Zodiac," *Archive for History of Exact Sciences* 64 (2010), 1–47.

⁵⁹ TCL 6 14, edited in Sachs, "Babylonian Horoscopes," Appendix II, pp. 65–75. In this text the synodic phenomena mentioned are first appearance (IGI) and last appearance (ŠU), otherwise the text refers to the planets rising (È) and setting (ŠÚ).

⁶⁰ TCL 6 13 rev. ii 28 gives the rubric "periodic occurrence of the enemy attack" (*adanni tib nakri*). For the word *adannu* "period," or "periodic cycle," see *The Assyrian Dictionary of the Oriental Institute of the University of Chicago* (Chicago, IL: Oriental Institute, 1956–2010).

⁶¹ For a text concerned with predicting market prices, see H. Hunger, *Spätbabylonische Texte aus Uruk* (Berlin: Mann, 1976), vol. 1, No. 94. For a text that predicts enemy activities (attacks and on which regions, whether or not booty will be taken, etc.), see TCL 6 13, in F. Rochberg, "TCL 6 13: Mixed Traditions in Late Babylonian Astrology," *Zeitschrift für Assyriologie* 77 (1987), 207–28. And for the prediction of rains and floods, see TCL 6 19 and 20, in H. Hunger, "Astrologische Wettervorhersagen," *Zeitschrift für Assyriologie* 66 (1976), 234–260.

⁶² TCL 6 20 obv. 16'–18' and rev. 9–10, see Hunger, "Astrologische Wettervorhersagen," p. 239.

EXPLANATION

Cuneiform scholarship developed modes of explanation appropriate to the various contexts and norms of its knowledge, and this had principally to do with texts. As divination was a scribal-scholarly endeavor it stands to reason that its development would involve philological techniques consistent with other scribal-scholarly practice. Ominous signs and cuneiform signs were related in the sense that both were to be read and interpreted. Explanation, therefore, took on a number of functions depending on different text types. Various, explanatory texts could focus on elucidation (of words by means of synonyms), exposition (of a phenomenon by means of description), or instruction (by means of the procedural steps involved in making, calculating, or performing something), all arguably subsumable under the rubric “explanation.” Explanation was a vital part of the cuneiform project of knowing and interpreting the world of signs, the correspondences between things, and the meaningful relationships between words and the world. In the form of commentaries and procedures, explanation found its way into other areas of scribal knowledge apart from divination, e.g., into mathematics, medicine, and astronomy.

Numerous reports from the Neo-Assyrian scholars refer to the explanation of omens with the term *pišru*, as in,

tonight Saturn approached the moon. Saturn is the star of the sun, (and) the relevant interpretation (*pi-še-er-šú*) is as follows: it is good for the king. The sun is the star of the king.⁶³

Other explanations in divinatory reports take the form of philological commentary on the words used in the omen text, as in the following, which first quotes an omen and then explains the verb (*terû* “pierce”) of its protasis:

If the moon’s right horn at its appearance pierces (*tirât*) the sky: there will be stable prices in the land; a revolt will be staged in the Westland. “Its right horn pierces the sky,” as it says, means it will slip into the sky and will not be seen; DIRI – pronounced dir – is “to slip,” said of a horn.⁶⁴

The explanation in the passage is the elucidation of the verb *terû* on analogical-phonological grounds with the verb *halāpu* (written with the logogram DIR) “to slip in or through.” The association to *halāpu* is based on the sound of its logographic spelling, whereby /*ter*/ can be associated with /*dir*/. The explanation of words in this fashion, by phonological

⁶³ Hunger, *Astrological Reports*, 95 rev. 1–7.

⁶⁴ *Ibid.*, 57: 5–rev. 4.

analogy and etymology, is quintessential cuneiform scribal philology, which stemmed ultimately from the translation methods of the compilers of lexical lists.⁶⁵

Astronomical texts have different predictive and explanatory properties compared to divinatory material. Given that they are both parts of the intellectual output of scribes, however, it is not surprising that they share a common intertextual nature. Exemplary of explanatory texts on the astronomical side are collections of procedures to explain rules for computing table texts, thus establishing an intertextual reference to the tables themselves. Also common to most procedural texts, as Ossendrijver pointed out, is the second-person address, as though in or from a dialogue, perhaps the vestige of an earlier rhetorical form.⁶⁶ The second-person rhetorical form also occurs in the context of omens, such as:

Observe his last visibility [on the 28th, variant: 29th of *Kislimu*], and you will predict an eclipse. The day of last visibility will show you the eclipse.⁶⁷

Using the same rhetorical device, the following procedure for a Jupiter 4-zone System A' model gives instructions for how to calculate longitudes with a step function, using the characteristic zone (or arc subdivision) boundaries for the planet, designated by zodiacal degrees:

From 9 Cancer until 9 Scorpius you add 30. (The amount) by which it exceeds 9 Scorpius you [multiply] by 1;7, [30].

From 9 Scorpius until 2 Capricorn you add 33;[45]. (The amount) by which it exceeds 2 Capricorn you multiply by 1;[4].

From 2 Capricorn until 17 Taurus you add 36. (The amount) [by which] it exceeds 17 Taurus you multiply by 0;56,15

From 17 Taurus until 9 «Cancer» [you add] 33;[45]. (The amount) «by which» it exceeds 9 Cancer you multiply by 0;53, 20.⁶⁸

In addition to the second person address, procedures referring to the subdivision of the synodic arc and describing the interval, or distance (*ZI = nishu*), a planet goes from one synodic phenomenon to the next within the total synodic cycle, called a “push,” expressed in distance (*biritu*) or days (*ūmū*), simply adopt a third-person descriptive style. Thus, from the same text (Ossendrijver No. 32), the four zones of the model are clarified:

⁶⁵ See the exposition of translation methodology in C. Jay Crisostomo, “Bilingual Education and Innovations in Scholarship: The Old Babylonian Word List Izi” (PhD thesis, University of California, Berkeley, CA, 2014).

⁶⁶ M. Ossendrijver, *Babylonian Mathematical Astronomy: Procedure Texts* (Berlin: Springer Verlag, 2012), p. 15.

⁶⁷ F. Rochberg-Halton, *Aspects of Babylonian Celestial Divination: The Lunar Eclipse Tablets of Ennuma Anu Enlil* (AfO Beiheft 22; Horn: Berger and Sons, 1988), p. 180.

⁶⁸ *Ibid.*, pp. 288–9, No. 32 lines 1–4.

From [9 Cancer] until 9 Scorpius the small one. From 9 Scorpius [until 2] Capricorn the middle one. From 2 Capricorn until 1[7] Taurus the large one. From 17 Taurus until 9 Cancer the middle one.⁶⁹

A late seventh century Goal-Year procedure text (BM 45728), perhaps the earliest such explanatory astronomical text known, gives sidereal periods for planetary synodic phenomena and corrections for the dates.⁷⁰ The tablet enumerates the periods for the appearances (IGI.DU₈.A = *tāmartu*) of the moon, Venus, Mercury, Mars, Saturn, and Sirius in a procedural manner. A selected passage reads:

[Appearance of] Venus. 8 years [you go back] behind you . . . 4 days you subtract. You observe (it).

[Appearance of] Mercury. Your 6 years you go back behind you . . . to it you add . . . 10 you add to the (date of) appearance. You observe (it).

[Appearance] of Mars 47 years you go back [behind you]; 12 days in addition [. . .] 10 you add to the (date of) appearance and you observe (it).

[App]earance of Saturn, 59 years you go back [behi]nd you. To the day (lit. “day by day”), (it = Saturn) appears (again).⁷¹

In the segment of the text quoted, the period for observing Venus is given as 8 years – 4 days, Mercury 6 years + 10 days, Mars 47 years + 12 days, and Saturn 59 years “to the day,” where the addition or subtraction of days is a feature of similar texts that correct for dates of observations, and the periods for Venus, Mercury, and Mars are those known in Goal-Year Texts.⁷²

Later astronomical procedure texts explain the computational methods of the ephemeris tables directly. The verbal idiom of late procedures is partly consistent with that of the divinatory tradition, for example in the phrase used to tell someone to take something into consideration, literally, “hold x in your hand” (*ina qātika tukāl*), or perhaps “bear in mind.” The contexts in which the phrase is employed can refer to a wind (or direction), times, positions, or a goal-year. The following shows its usage in *Enūma Anu Enlil* Tablet 20: “You observe his (the god’s) eclipse and bear in mind the north

⁶⁹ Ibid., No. 32 lines 5–6.

⁷⁰ J. P. Britton, “Treatments of Annual Phenomena in Cuneiform Sources,” in J. M. Steele and A. Imhausen (eds.), *Under One Sky: Astronomy and Mathematics in the Ancient Near East* (Münster: Ugarit Verlag, 2002), pp. 21–78, Appendix A, pp. 59–61.

⁷¹ BM 45728: 5–14. Cf. translation in Ossendrijver, *Babylonian Mathematical Astronomy*, p. 23.

⁷² J. M. Steele, “Goal-Year Periods and their Use in Predicting Planetary Phenomena,” in G. J. Selz with the collaboration of K. Wagensonner (eds.), *The Empirical Dimension of Ancient Near Eastern Studies/Die empirische Dimension altorientalischer Forschung* (Vienna and Berlin: LIT Verlag, 2011), pp. 101–10, p. 105.

(IM.SI.SÁ ina ŠU-ka tu-kal).⁷³ In the late astronomical procedures, times and positions are to be “held in one’s hand (or hands),” as in Ossendrijver’s Procedure Text No. 46 (= ACT 812) rev. ii 1–2: “The day when Venus appears in the west (EF) or sets in the east (ML): you hold the times and positions for the *igigubbú*-coefficients [. . .] in your hands.”⁷⁴

Another feature shared with the divinatory corpus was the collection of explanatory texts into series. Some explanatory texts, such as the “commentary” (*mukallimtu*) or “explanatory word list” (*šātu*), constituted multi-tablet series of their own, and a few astronomical procedure texts appear to similarly belong to series.⁷⁵ A set of procedures referring to Saturn, giving a number of procedures explaining Systems A, B, and B” for Saturn, has a colophon with the catchline for the next tablet in the series, with an incipit “the displacement (or progress in longitude) of Mars.”⁷⁶ Similar to the interpretative material prepared and collected for intuitive predictive texts (omens), the mathematical tables too had an interpretative corpus prepared and collected as procedures.

An exploration of the context of explanation must recognize the importance of schemes (both divinatory and numerical), models, and analogies (both divinatory and numerical). As divination and astronomy both had predictive aims, explanation was embedded in the predictive undertaking. Each branch of cuneiform predictive knowledge was tied to programs of observation and a tradition for recording and dating those observations. From our point of view, observation, prediction, and explanation belong within the purview of science. Although the methods of investigation into the world of perception and experience, and ideas of what was usual, unusual, regular, irregular, normative, and anomalous were determined by the particular phenomena – mostly ominous phenomena – that interested the Assyrian and Babylonian scholars over time, in terms of the empirical, predictive, and explanatory dimensions of cuneiform knowledge, particularly in its persistent attempts to grasp an order of things and to resolve what is anomalous into a system, it is hardly possible not to see the features of its kin in the later history of science.

MODERN NOMENCLATURE OF BABYLONIAN ASTRONOMICAL/ASTROLOGICAL TEXTS

Since Neugebauer’s pioneering work first to publish the cuneiform ephemerides and procedure texts,⁷⁷ and then to incorporate this material into

⁷³ Rochberg-Halton, *Aspects*, p. 241.

⁷⁴ Ossendrijver, *Babylonian Mathematical Astronomy*, p. 329, No. 46 rev ii 1–2.

⁷⁵ *Ibid.*, p. 12.

⁷⁶ *Ibid.*, p. 310, No. 42 rev. 7.

⁷⁷ Neugebauer, *Astronomical Cuneiform Texts*.

a treatment of ancient mathematical astronomy alongside Egyptian, pre-Ptolemaic, and Ptolemaic Greek astronomy,⁷⁸ cuneiform astronomical texts have attained a pride of place in the history of ancient science for their quantitative and predictive nature, their use of period relations for lunar and planetary synodic phenomena, their use of number-theoretic functions for construction of predictive models for the calculation of these periodic lunar and planetary synodic phenomena, and the direct influence they had on Greek astronomy.

An effective classification scheme for the Babylonian astronomical texts was introduced in 1948 by Abraham Sachs in what is by now a classic paper.⁷⁹ There, Sachs divided the corpus of Seleucid astronomical tablets into tabular and non-tabular texts. The “Astronomical Tables” included planetary and lunar ephemerides, which were recognized as intimately related to procedural texts.⁸⁰ Sachs’ study and classification of the astronomical texts began with the problem of distinguishing between observations and predictions, and he stated that “a somewhat startling result is that all classes of Seleucid astronomical texts contain at least some predictions.”⁸¹ It is in the methods of prediction that the texts are to be differentiated, in the tabular texts by the use of linear functions based on period relations and in the non-tabular texts by a simpler use of appropriate (synodic or sidereal) periods (goal-year periods) for the astronomical body in question.

In 1980 Asger Aaboe revisited the question of the relation of observation and prediction.⁸² His goal was to explain how the excellent mathematical schemes of the Seleucid Babylonian ephemerides could have been derived from what he called the “crudity” of observational data in the texts he termed “non-mathematical astronomical texts,” i.e., in the very same set of sources classified as “non-tabular” by Sachs, principally, the Diaries. The “non-mathematical astronomical texts” were to be differentiated from the texts in Neugebauer’s ACT volume on the basis that they were largely observational, whence the distinction of mathematical versus non-mathematical astronomical texts. Aaboe’s distinction rested on the difference between the singular and theoretical nature of the ephemerides’ mathematical schemes on the one hand and the (non-mathematical) largely observational data of the Diaries on the other. His question was: how might the Diaries have served as a possible source for the development of the mathematical schemes of the ephemerides?

Sachs’ terminology, however, referred to format not content, and emphasized the fact that both tabular and non-tabular texts contain predicted data. Thus it is not the case that only the ACT texts are quantitative and

⁷⁸ Neugebauer, *A History of Ancient Mathematical Astronomy*.

⁷⁹ Sachs, “A Classification of Babylonian Astronomical Tablets.”

⁸⁰ *Ibid.*, p. 273.

⁸¹ *Ibid.*, p. 271.

⁸² Asger Aaboe, “Observation and Theory in Babylonian Astronomy,” *Centaurus* 24 (1980), 14–35.

predictive. Their distinguishing feature is the highly developed use of functions (zigzag and step) in the form of difference sequences to generate positions in the zodiac or dates in the year (using months and a mathematical unit $1/30$ of a month, termed “tithi” after its Sanskrit coinage, and fractions of tithis).⁸³ The non-tabular astronomical texts (i.e., Aaboe’s non-mathematical astronomical texts, also referred to by Neugebauer as GADEX texts⁸⁴), though comprised largely of observations, also contain predicted data derived from the use of numerical parameters, based in turn on a knowledge of planetary and lunar periods.

A distinction between mathematical and non-mathematical for cuneiform astronomical texts may well be useful in that the numbers in the tabular texts (ephemerides) reveal the quantitative methods (zigzag and step functions), predictive goals (dates and positions of synodic phenomena of the moon and planets), and theoretical quantities (mean synodic arc or mean synodic time) or constructs (the mean sun) associated with and exclusive to mathematical (or tabular) astronomical texts. That distinction, however, should not obscure the broader relationships among astronomical, astrological, as well as medical, magical, and divinatory texts. Intertextual connections, both direct (references in Diaries to ominous events) and indirect (calculations for planetary positions given in horoscopes), point to a more integrated culture of knowledge.

Observational and predictive, as classificatory descriptors, therefore apply to two closely related approaches to astral knowledge that not only complemented one another from the beginning of the history of Babylonian astronomy but had some relation to divination as well. Early Babylonian astronomy aimed to schematize and model phenomena consistent with ominous signs, such as the appearances and disappearances of Venus formulated as omens in *Enūma Anu Enlil* 63. Later, in Goal-Year Texts, Diaries, and Almanacs, the phenomena that were predicted (to supplement those observed) were the synodic appearances of the planets, their passages by Normal Stars, Lunar Threes, Lunar Sixes, and eclipses. In the ephemerides, synodic phenomena of the moon and planets were calculated by means of mathematical models based on period relations and the use of zigzag or step functions. It is important to note that these phenomena do not appear as such in omen texts.

Terms associated otherwise exclusively with astronomical texts, such as “latitude” (NIM “high” and SIG “low”) and the Lunar Three (length of the previous month, expressed as either 30 or 1, mid-month *na*, i.e., the *na*

⁸³ Of course, foreshadowing of these methods can be seen earlier, though at a much cruder level, for example in *Enūma Anu Enlil* 14 (see note 61) and the Astrolabe Daylight scheme, both of which employ zigzag functions. A later extension of this method can also be seen in a group of *zigu* star texts that deal with the problem of zodiacal rising times; see Rochberg, *In the Path of the Moon*, pp. 271–302.

⁸⁴ See Neugebauer, *A History of Ancient Mathematical Astronomy*, p. 351.

opposite the sun, and KUR, the time between the last visible moonrise before conjunction and sunrise) do, however, appear in Late Babylonian astrological contexts, e.g., horoscopes. In the case of latitude, the horoscopes refer only to lunar latitude,⁸⁵ but a late Uruk omen text clearly deals with the relevance of planetary latitude for the forecasting of market prices, as follows:

If Jupiter is faint, or attains minimum latitude, or disappears, and Mars is bright or attains maximum latitude, or Mars and Jupiter are in conjunction: Business will greatly decrease and the people will experience severe famine.⁸⁶

What emerges is that the earliest selective attention to phenomena, especially but not exclusively of the heavens, comprised a number of separate but interdependent strands of knowledge and practice – divination, astronomy, and astrology – each of which took complex forms and utilized a variety of methods. Each played a role in the scribes' engagement with the world over the millennia of their tradition. That engagement centered on the search for and understanding of order and anomaly within phenomena, both in order to observe and interpret phenomena as signs and to predict those that were periodic.

⁸⁵ Rochberg, *Babylonian Horoscopes*, pp. 42–3.

⁸⁶ Hunger, *Spätbabylonische Texte aus Uruk*, vol. 1, Text 94: 12–14.