Science, Mesopotamian

MATHIEU OSSENDRIJVER

Mesopotamian science covers all forms of scholarly inquiry into natural and cultural phenomena, both real and imagined. This inclusiveness reflects the nature of Mesopotamian scholarship as well as a consensus among most modern historians and philosophers of science about the impossibility of defining consistent and non-anachronistic criteria for distinguishing science from "pseudoscience." Mesopotamian science, therefore, includes not only mathematics, astronomy, medicine, and pharmacology, but also lexical lists, astrology, divination, annalistic historiography, and arguably even theology and rituals, which cannot all be addressed here for lack of space.

LEXICAL LISTS

The earliest evidence of scholarly inquiry in Mesopotamia is contained in lexical lists, which are the oldest known cuneiform texts (3200 BCE) apart from bookkeeping records. These originally monolingual (SUMERIAN), later bilingual (plus AKKADIAN) compilations of CUNEIFORM signs and words exhibit various degrees of systematization of natural and cultural phenomena based on orthographic or semantic principles.

DIVINATION

Mesopotamian divination (*see* DIVINATION, ANCIENT NEAR EAST) is based on the belief that the gods communicate with man through signs (omens), which could be found in all realms of nature and culture. Diviners used written collections of omens for extispicy, celestial phenomena, medical diagnostics, abnormal births (*see* ŠUMMA IZBU) and daily life (*see* ŠUMMA ĀALU) when interpreting signs. Although omens do reflect systematic exploration of natural phenomena, their empirical content is limited, since many are clearly constructed or describe impossible phenomena (Brown 1998).

Celestial divination is first attested in the Old-Babylonian period but already referred to in Sumerian literary compositions from 2400–2000 BCE. By 1000 BCE a process of elaboration had resulted in the astrological omen series *ENUMA ANU ENLIL* comprising 70 tablets. The structure of an omen can be illustrated by an example from tablet 33: "If a solar eclipse occurs on day 1 of the month Nisan the king of Akkad will die." We are well informed about the use of celestial divination by Neo-Assyrian rulers due to numerous reports (Hunger 1992) written by the astrologers to king Assurbanipal (*see* LIBRARY OF ASSURBANIPAL). In these reports celestial divination comes across as an integral part of the Assyrian religion and state ideology that enabled the king to present his rule as being in line with the decisions of the gods. Astrologers constantly advised the king about recently observed signs and their ritual, political, military, or medical implications. In case of an unfavorable sign apotropaic rituals were available. An eclipse could mean acute danger that called for the so-called substitute king ritual, requiring the king to temporarily step down from his throne and be replaced by a commoner, usually a prisoner, who was to bear the evil.

MATHEMATICS

Mathematical texts from the Old-Babylonian period (1800–1600 BCE) (*see* MATHEMATICS, MESOPOTAMIAN) include tables of multiplication, reciprocals, squares, etc., expressed in the sexagesimal place-value notation, invented in the preceding Ur-III period. In some problem texts systems of unknowns, equivalent to modern quadratic or more complex equations, are solved using so-called geometrical algebra. Many of these transcend the practical needs of bookkeeping. Other common topics of the problem texts include metrology, inheritance, and various types of riddles.

MEDICINE

Mesopotamians construed human disease and medical conditions as signs that must be interpreted like other phenomena. Diagnostic handbooks (*see* MEDICINE, MESOPOTAMIAN) are thus collections of omens through which diseases are attributed to various supernatural influences. They were used by the exorcist (*asipu*), and reflect a profound knowledge of the phenomenology of human disease. Therapeutic and pharmacological texts, which testify to detailed knowledge of herbs, belong to the realm of the physician (*asu*), who collaborated with the exorcist in the healing of the patient.

CALENDARS

Calendar issues contributed to the development of astronomy. Mesopotamians used a luni-solar calendar in which the month began with the first sighting of the lunar crescent. Since 12 months amount to about 354 days – 11 days short of the solar year – it was necessary occasionally to insert an extra month. From about 1400 BCE onwards starlists known as "astrolabes" provide an ideal calendar listing three heliacally rising constellations for every month of the year. Mulapin("Plough Star") is a compendium comprising three tablets about various astronomical, calendrical, and astrological topics (Hunger and Pingree 1989). By the sixth century BCE Babylonian astronomers had implemented an accurate nineteen-year ("Metonic") intercalation cycle whereby one extra month is inserted in seven out of nineteen years. The desire to predict the first appearance of the lunar crescent rather than depend on observation contributed to the development of the Goal-Year method (*see* GOAL-YEAR TEXTS) and mathematical astronomy, two sophisticated predictive methods to be discussed below.

OBSERVATIONAL ASTRONOMY

Probably the earliest known records of astronomical phenomena (seventeenth century BCE) are Venus observations contained in the so-called Venus tablet of Ammisaduqa (*see* AMMISADUQA, VENUS TABLET OF). Astronomical diaries and related observational texts from Babylonia are the fruits of a systematic program of observation that began near 750 BCE and continued until the first century CE. Diaries usually contain six months of observations, each month beginning with a section covering daily positions, lunar phenomena including the first sighting of the crescent, and the synodic phenomena of the planets (*see* DIARIES, ASTRONOMICAL; Hunger and Sachs 1988–2006). These data were used for predicting the same phenomena for a future year using the Goal-Year method, which is based on accurate periods after which the phenomena repeat at nearly the same celestial position and calendar date. Goal-Year predictions are thus essentially observations excerpted from diaries preceding that year by the appropriate period.

One instrument for measuring time used by the Babylonian astronomers is the sundial, which casts a shadow whose length and angle are measures of the time lapsed since sunrise. The waterclock is a water-filled container with a tiny hole near the bottom, so that the weight of the escaped water is a measure of time. A third method, for measuring time at night, is based on lists of time intervals between successively culminating "ziqpu" stars. There must have existed a simple instrument for measuring angular distances similar to the medieval Jacob's staff. From the Achaemenid period onwards, when the astronomers are known to have been temple employees, the temple towers (ziqqurats) might have been used as platforms for observation.

MATHEMATICAL ASTRONOMY AND ZODIACAL ASTROLOGY

Near 450 BCE, when Babylonia was under Achaemenid control, the astral sciences saw further substantial developments along with the introduction of the zodiac, a division of the ecliptic (the sun's orbit) into twelve

sections of 30° named after nearby constellations. Tablets from BABYLON and URUK contain the earliest known form of mathematical astronomy. Times and positions of the same lunar and planetary phenomena known from the diaries are now predicted with mathematical algorithms. The latter are preserved in procedure texts (Ossendrijver 2011), the predictions in the form of numerical tables. Babylonian zodiacal astrology includes forerunners of the horoscope (Rochberg 1998), in which the future of a newborn is derived from the positions of the planets at the day of birth. Terrestrial phenomena such as weather, the river gauge, market prices of certain goods, and historical events, all of which were recorded in the astronomical diaries, were also meant to be predicted, by assuming that they are correlated with astronomical phenomena, as is explicitly mentioned in certain texts.

TRANSMISSION OF BABYLONIAN ASTRAL SCIENCES TO THE GRECO-ROMAN WORLD

Babylonian astronomy and astrology were transmitted to the Greco-Roman world, where the word "Chaldaean," originally designating the inhabitants of Babylonia, became synonymous with "astrologer." The astronomer HIPPARCHOS (second century BCE) used Babylonian astronomical data and introduced sexagesimal calculus into Greek astronomy. PTOLEMY (second century CE) acknowledged Babylonian observations as a source of certain astronomical parameters underlying his famous Almagest. The horoscope and various elements of Greco-Roman astrology turn out to be imported from Babylonia (Rochberg 2004). Babylonian mathematical astronomy is attested in Greek papyri from Greco-Roman Egypt found in OXYRHYNCHOS (Jones 1999).

SEE ALSO: Assyria; Calendar, ancient Near East.

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