Originalveröffentlichung in: P.T. Keyser, J. Scarborough (Hrsg.), The Oxford Handbook of Science and Medicine in the Classical World, Oxford 2018, S. 61-70; Online-Veröffentlichung auf Propylaeum-DOK (2022), DOI: https://doi.org/10.11588/propylaeumdok.00005336

CHAPTER A2B

ASTRONOMY IN ANCIENT EGYPT

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ALTHOUGH classical (Greek and Latin) sources tend to characterize Egypt as a culture with substantial astronomical (and astrological) knowledge, the actual Egyptian sources are much less obvious in this sense. This fact has led some scholars to say that Egypt has no place in the history of mathematical astronomy (Neugebauer 1975, 559). However, things are more complicated, and several important points have to be kept in mind (Quack 2016).

First, in many cases, astronomical phenomena are integrated as parts of religious conceptions (von Lieven 2000). That makes them much more difficult to decode and often gives rise to suspicion by the historian of science.

Second, our record of preserved Egyptian texts is seriously distorted in favor of material from tomb contexts, but pure astronomical texts are not among the most likely candidates to be found there. As soon as material from settlements is available in substantial numbers (especially for the Greco-Roman period), astronomical texts tend to be present.

Third, many of the sources are remnants of the practice without indicating the theory behind them, for example, lists of stars. This means that many of our overall conclusions are based on inference.

1. Calendars and Constellations

It can be assumed that some basic astronomical facts were known in Egypt from very early times, especially those directly relevant for timekeeping. The Egyptian calendar is, unlike most other ancient cultures', not primarily based on the moon. Rather it has uniformly 365 days (without any intercalary days), divided into three seasons each of four months, with 30 days per month, and at the end of the year five special days outside of the normal structure. This is the closest fixed-length approximation to the actual year-length possible and likely based on astronomical observations of either the sun or the stars.

It can be debated to what degree there was originally a lunar calendar in use in Egypt. For as far back as we have sufficient documentation, the civil calendar is dominant, although there is a lunar cycle, beginning on the day of the moon's invisibility, and used for some aspects of religious life (especially temple service and a few festivals). Since there is no continuous count of years, and the lunar months are kept in close relation to their civil counterparts, it is not really justified to speak of a genuine lunar calendar. The waxing and waning of the moon was conceptualized as gods entering and leaving the celestial eye (von Lieven 2000, 127–132).

Since the lunar cycle had relevance for some religious feasts, it was observed in the temples and served, from the later Middle Kingdom (about 1850 BCE) onward, as the organizing principle for temple service (with change of staff always on the second day of the lunar cycle). While for the older periods it is probable that it was based on actual observation, at least for the Greco-Roman period there were schematic 25-year cycles that worked well to keep the lunar cycle in line with the nonintercalated Egyptian year of 365 days. A famous example of a schema is Papyrus Carlsberg 9 (for the interpretation, see Depuydt 1998b), but there is good documentation that slightly different methods were also in circulation (Lippert 2009; Bennet 2008). Those schemes specify how 29- and 30-day lunar months should follow each other, and when there would be a "big year" containing 13 lunar months.

Celestial regions and stars play a substantial part already in the oldest corpora of religious texts preserved from ancient Egypt (Krauss 1997; Wallin 2002), but their location and identification with our star terminology is fraught with difficulties. The most important stars and constellations were Orion (connected with Osiris, the god who was killed by his brother), Sirius (connected with his sister and wife Isis), and the Big Dipper (connected with the murderer Seth).

Sirius (called Sothis in Egyptian) had a special role because its heliacal rising coincided with the ideal Egyptian New Year day that was linked with the onset of the Nile inundation. It is likely that the specific phenomena of its appearance (like radiance, and in later periods planetary positions) were used for divinatory purposes, although unequivocal documentation exists only for the Roman period (Quack, forthcoming, a).

2. Star Clocks and Decans

The oldest explicitly astronomical monuments from Egypt are star clocks, attested by more than 20 copies, mainly on the inner side of coffin lids from the Eleventh and Twelfth Dynasties (ca 2050–1900 BCE) (Neugebauer and Parker 1960; Quack, forthcoming, a). They indicate, in principle, for each 10-day interval of the year a sequence of 12 stars (or parts of constellations), with each star moving up one position in the table per interval. It is generally assumed that a significant astronomical position of the star (most probably its rising in the east) indicates the onset of a new hour of the night. The "hours" are rather short hours of about 40 minutes, so that a change by one "hour" for a star every 10 days corresponds more or less to astronomical reality. These stars (or parts of constellations) have a long history and still appear in some astrological treatises of classical antiquity. They are commonly called decans (as they are in Greek and Latin texts), while the Egyptian designation is *baktiu* "those connected with work"—the "work" being the indication of the hours; often they are simply labeled in the texts as "stars" without further specification. The images seen in the sky by the Egyptians differ significantly from our modern tradition (mainly derived from Mesopotamia and Greece), and the identification of most of the Egyptian constellations is fraught with difficulties (a recent proposal is in Lull and Belmonte 2006). Observing the hours of the night was important mainly for the performance of some religious rituals.

There are two basic types of the oldest star clocks, with some differences in the actual choice of decans and a divergent starting point. It is likely that this does not reflect different dates of invention (as supposed earlier by Neugebauer and Parker 1960); rather, both structures are equally schematic, with the one putting the heliacal rising of Sirius in the middle of the table, the other putting Sirius as the last regular star in the top line.

A different type of star clock is constituted by the "Ramesside star clocks" (Neugebauer and Parker 1964; Leitz 1995, 117–287; Depuydt 1998a). They are only attested in three royal tombs of the 11th century BCE, but thought by astronomical considerations (especially the rising date of Sirius) to go back to the 15th century BCE. They are also based on stellar position but show several refinements. The individual tables are no longer for 10 but for 15 days, which makes them more suitable for fixed hours of 60 minutes. They use the culmination as principal marker of hourly changes but allow also other positions, which are defined in terms of human anatomy (like "left eye" or "right ear") and probably refer to a human statue set up directly opposite the observer as a marker of the meridian; so these would indicate positions of the star more or less distant from precise culmination.

Only attested on one single monument from the 4th century BCE is a type of stellar clock that divides the night only into three parts, based on the movements of the Big Dipper (Neugebauer and Parker 1969, 49–52). The actual engraving shows serious corruption.

3. *The Book of Nut*

The most complex composition concerning celestial phenomena is constituted by the "fundamentals of the course of the stars" (von Lieven 2007), also known under the name *Book of Nut*. This composition is attested in three monumental versions (13th, 12th, and 6th centuries BCE) as well as a number of papyri of the Roman period (2nd century CE), plus an excerpt of a short passage attested in some tombs of the Twenty-Sixth Dynasty

(Régen 2015); another short extract is attested on the ceiling of the temple of Athribis in the Ptolemaic period. Two of those papyri (Papyrus Carlsberg 1 and 1a) contain not only the basic text but also a translation into a more recent form of Egyptian, plus a commentary (not identical in the two sources). The monumental versions (and one papyrus with hieroglyphic writing) also show a picture of the sky goddess (Nut) lifted into the air by her father (Shu); the demotic papyri describe this image without drawing it.

The first part consists of relatively short texts accompanying parts of the drawing. The first section of this part describes phenomena of the sun, especially its rising in the morning; the redness in the morning is equated to hemorrhage during a birth. This is followed by a short description of the outer parts of the sky where the sun does not shine.

A substantial section treats the stars, especially the decans. They are pressed into a schematic template where each decan spends, after its heliacal rising, the first 80 days in the eastern part of the sky, then his culmination serves, for 120 days, to indicate nightly hours, and afterward, he spends 90 days in the western part of the sky, before being invisible for 70 days. This is obviously not to be taken as numerically exact, and it works with a rounded year-length of 360 days (neglecting the final five days of the Egyptian year outside normal calendrical structure) in order to keep the calendar dates simple. Still, it shows that the Egyptian decans should be located in a celestial belt south of the ecliptic (Neugebauer and Parker 1960, 97–100).

The description of the cycle of the sun is resumed, this time focusing more on sunset and night, but continuing until sunrise. It is explained how the stars are following the sun. Finally, there is a section about the migratory birds which are understood as the souls of men, coming from the north to feed on the herbs of Egypt.

The second part of the composition is contained in only one of the monumental versions, separated from the first part by passages about a shadow clock and a water clock, whereas the papyrus texts continue directly after the first part. The general style of the second part is more mythological than the first one, and there are longer connected texts. The disappearance of the stars is conceptualized as their consumption by a mother sow, their stay below the horizon as a purification. After the treatment of the stars, a section on the moon follows where the phases are mainly explained as interactions between different deities, for example, Horus and Seth. The final preserved section was understood as treating the moon and the planets by von Lieven (2007, 107–119, 190–201; 2012, 120f.), while Leitz (2008/2009, 17–19) preferred to see it as another treatment of exclusively the moon.

4. Sky Ceilings

There is a standard program for decorating astronomical ceilings of coffins, burial chambers, or temple rooms (and the outer sides of water clocks), which is attested by a few cases already from the Twelfth Dynasty (ca 20th century BCE), and much better from both the New Kingdom and the Late Period (i.e., ca 1500–150 BCE) (Neugebauer and Parker 1969). The image is divided between a north and a south side. On the north side, in the center, a few northern constellations are shown, the most important one being the Big Dipper kept on a chain by a hippopotamus goddess, a crocodile, a lion, and a falcon-headed god. Left and right of them, there are deities who are perhaps personifications of days of the month (never a complete set), although in one late monument they are labeled as "circumpolar stars." Sometimes, the months are also represented. The chaining of the Big Dipper refers to its never-setting stars, and the constellation was understood as being unable to descend into the netherworld where Osiris is (von Lieven 2000, 24–29). A spell invoking Thot, the god of time-keeping, and threatening to reveal that he has slackened the chains so that the Big Dipper could actually go down in the west, might show the observation of the effects of precession, which led to some of its stars dipping below the horizon in southern Egypt from the late second millennium BCE (Waitkus 2010, 179), even though the Egyptians did not formulate any theoretical model of the precession.

On the south side, there is the sequence of the decans, often with their tutelary deities. A few of the more important decanal constellations are represented by images, especially the Ship, the Sheep, and the Two Tortoises. Also found on the south sides are depictions of the five planets known in antiquity. These distinguish the inner and the outer planets, but the outer ones are not arranged according to distance from the sun. The epithets given to them should not be understood as permanent ones but as valid for a specific situation, like "star of the southern sky" or "he walks backward"—the latter showing observation of the phenomenon of retrograde movement. It seems as if a quite specific situation has served as model for future craftsmen even long after it had lost its pertinence. Attempts to date these depictions to specific historical moments have failed.

5. Simple Formulae

Beginning in the New Kingdom and attested still in copies dating from the 2nd century CE, there are examples of linear zigzag functions for defining the length of the day and night in different months of the year (Quack, forthcoming, b). The values used seem often more driven by the desire for numerically simple solutions than for precision. Thus, one has an increase of 2 hours per month, another one 1 1/3 hours per month, which leads to extreme ratios of 18:6 or 16:8.

A hieroglyphic inscription of the Late Period from Tanis gives some astronomical parameters (Clère 1949; Hoffmann 2016). The best preserved parts concern the length of day and night in 15-day steps. The specific values seem to be borrowed from Mesopotamian traditions (Hoffmann 2016). Other parts correlate specific decans with the onset of night.

Only in the late 2nd century CE do we have Egyptian-language testimonies for a calculation of the divergences of day-light from month to month which do not work in a linear way but indicate different fractions of change for each month (Naether and Ross 2008), going from 1/16 to 1/12.5.

A papyrus of the Late Period (ca 650–550 BCE) from Elephantine (P. Berlin 23050) indicates values (expressed in fractions) for the distance between different decans as well as within a decan constituted by several individual stars (Quack in press a). While the numerical values as such are not easily understandable, the system seems to show similarities to the Mesopotamian system of *ziqpu*-stars where fractions of the volume of water in a water-clock are used to indicate time- and space-distances.

6. Materials of the Greco-Roman Period

In the Greco-Roman period, Egyptian astronomy receives substantial impact from the Near East, but at the same time developed further what it received and probably played an important role in transmitting it to the Greeks (Greenbaum and Ross 2010, Quack, forthcoming, b). The most important new element was the zodiac. The first indications for its presence in Egypt can be found on a demotic ostracon (Strasbourg D 521) that correlates the Egyptian months with the zodiacal signs. The dates work best for the early Ptolemaic period, although palaeographically, the actual text is likely to be later. Another, still unpublished text from Roman period Tebtunis (Papyrus Carlsberg 769) gives a correlation of months and zodiacal signs that works according to the Alexandrian calendar.

Also, a number of constellations were taken over from other cultures and appear mixed with traditional Egyptian ones on the round and the rectangular zodiac of Dendara. They are more likely to come directly from Mesopotamia than from Greece (Quack, forthcoming, b against Leitz 2006). A number of the specific Egyptian constellations attested on ceilings of temples appear also in the Greek and Latin lists of the so-called sphere barbarica, that is, non-Greek constellations.

A late Ptolemaic papyrus gives, on one side, a list of lunar eclipses (Neugebauer, Parker, and Zauzich 1981) that are dated according to the fourth Callippic period (Jones 1999, 14). The other side correlates Egyptian calendar dates to the seasonal turning points (Parker and Zauzich 1981). It is stylized as a mathematical exercise text. The length of the respective seasons is given as 93, 90, 90, and 92 days.

Especially for the Roman period, we have a situation in Egypt where Greek and demotic Egyptian language and script can be equally used for astronomical and astrological texts (Jones 1994; Jones 1999; Quack forthcoming, b). Sometimes, there is even clear evidence that manuscripts in Greek were actually used in the framework of Egyptian temples. Many of them use methods derived from Mesopotamian models (Jones 2001; Jones 2002; Hoffmann and Jones 2009) and are based on arithmetic models in contrast to the kinematic ones known especially from Ptolemy.

There are a few procedure texts for making calculations; among the preserved ones in Egyptian, there is a calculation for Jupiter and the moon (Neugebauer and Parker 1969, 250–52), as well as a recently discovered still unpublished text from Tebtunis that gives indications about the calculation for Venus.

The more important tables are epoch tables (indicating successive occurrences of a specific event of a planet), templates (giving day-by-day progress), ephemerides (giving day-by-day positions), sign-entry almanacs (providing dates when a planet moved to a new zodiacal sign), monthly almanacs (giving the positions and significant events of the planets) and five-day almanacs (giving planetary positions). Most of them are by now also documented in Egyptian.

It should be stressed that all these tables used for calculating the positions of the planets were not intended as exercises in themselves but served for practical use in astrological forecasts. A substantial number of astrological treatises (many of them still unpublished) are preserved, most of them in demotic Egyptian (Ross 2007; Winkler 2009; 2016). Those discussing individual destinies are normally based on the position of the planets in the houses of the dodecatropos (see *Astrology, C09*, sec. IX.A.1) or of the decan at the time of birth. Also actual horoscopes on papyri and ostraca are attested in substantial numbers both in Egyptian and Greek.

The importance of astrological conceptions can also be seen in the fact that astronomical ceilings of public monuments (temples) tend to depict the planets in positions that correspond to theories about the planetary positions at the moment of the birth of the cosmos. Private monuments (tombs and coffins), if they depict astronomical positions, tend to show the planets at the moment of the birth of the owner.

Little is known about the social position of astronomers (Fissolo 2001; Dieleman 2003; Evans 2004; Winkler 2016). We can suppose that they were normally part of the temple staff.

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