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ESSAY REVIEWS

A HISTORIAN'S HISTORY OF ANCIENT EGYPTIAN SCIENCE

Essay review of:

MARSHALL CLAGETT, *Ancient Egyptian Science. A Source Book*. Volume One: *Knowledge and Order*, 2 tomes (Memoirs of the American Philosophical Society, 184), Philadelphia, American Philosophical Society, 1989. Chronology, Bibliography, Index of Egyptian Words, Index of Proper Names and Subjects, xv+736 pp., 127 pp. illustrations.

MARSHALL CLAGETT, *Ancient Egyptian Science. A Source Book*. Volume Two: *Calendars, Clocks, and Astronomy* (Memoirs of the American Philosophical Society, 214), Philadelphia, American Philosophical Society, 1995. Bibliography, Index of Egyptian Words and Phrases, Index of Proper Names and Subjects, xiv+575 pp., 146 pp. illustrations.

The volumes under review represent the scholarly facet of that *vita nuova* in which the author engaged after finishing his monumental *Archimedes in the Middle Ages* in five volumes and many more tomes (the dedication «For Sue Once Again» tells us that the impressive work they must have asked for has fortunately left space for other facets). Let it be said at once that they constitute the beginnings of a worthy successor – the planned third volume will deal with mathematics, medicine and biology, and contain a «detailed presentation of Egyptian techniques for representing nature» [I:x].¹

¹ I shall use this simplified reference system for all quotations from the two volumes. Everywhere in the following, 'Egyptian' means 'ancient Egyptian'. Datings follow the chronology of [I:629-635], and thus in the main J. BAINES, J. MÁLEK, *Atlas of Ancient Egypt*, Oxford, 1980, pp. 36-37, and O. NEUGEBAUER, R.A. PARKER, *Egyptian Astronomical Texts*, 3 vols, Providence & London, Brown University Press, 1960-69, vol. I, p. 129; 'D.' stands for 'Dynasty', which remains the most adequate frame of reference for Egyptian relative chronology. In the chronology adopted, the Old Kingdom (D.3-D.8) is 2664-2155 BCE, the Middle Kingdom (D.11-D.13) covers 2040-1640 BCE, and the New Kingdom (D.18-D.20) 1550-1070 BCE.

The original idea was to «produce a Source Book in Ancient Egyptian Science consisting of enough extracts to illustrate some of the aspects of that science» [I:ix]. However, on the premise that the interesting questions are «the nature of Egyptian scientific knowledge and the procedures to acquire that knowledge» [II:307] as well as the «intent» of the Egyptian scholars [II:424], the author realized that «a few documentary extracts were insufficient to give a historian of science without any special knowledge of the Egyptian language and culture a well-rounded view of the growth and development of that science» [I:ix].

Each section of the work thus starts with an extensive 'chapter' which discusses its theme broadly and in depth. A number of documents in translation follow, each provided with a specific introduction. All translations are prepared by the author, often following existing translations into modern languages closely but deviating from these when required, e.g., in the interest of consistency between documents, and always with a critical eye; at times, the translation builds on a more complete Egyptian text than previous translations. Chapters, introductions and documents are provided with copious notes, meant to «illustrate the historical steps taken by earlier scholars to advance our knowledge [...] not only to give the reader a good sense of the development of scholarship over the last two centuries but also to give honor and credit [and, when appropriate, criticism/JH] where they are due» [II:ix]; by way of this presentation of earlier views and debates, the notes provide ample opportunity for philological commentary and critical discussion (also in cases where Clagett suggests new readings or interpretations). Some of the documents represent complete texts, others such excerpts as are deemed relevant for the theme to be illustrated. No doubt these annotated translations will allow «readers without detailed knowledge of the original language, i.e., most students of the history of science, a good sense of what the documents intend», while «the reader who controls the Egyptian language» will find most texts from Volume Two and some from Volume One in original or in hieroglyphic transcription in the illustrations [II:viii]. Of particular value is the observation that certain expressions are commonplaces – if such a warning was not given [e.g., I:186, n.8], the student with no broad acquaintance with the style of Egyptian documents might be induced to take at automatic face value the claim of the constructor of a Middle Kingdom water clock that «never was made the like of it since the beginning of time» [II:460], Clagett's cautious doubt notwithstanding (cf. below).

The title of Volume I (*Knowledge and Order*) «translates a pair of crucial Egyptian words: *rekh* [...] and *maat* [...]» [I:xi]. *rekh*/'knowledge' refers to the normative ideal – the ability to measure, count, and record – of scribal workmanship. *maat*/'order' encompasses in one densely packed concept the notions of cosmic, political and social justice or order. Since Egyptian 'science' was always the preserve of the scribal craft, and its scope was often to describe or upkeep the order of the world, these two concepts were certainly «important

aspects of the Egyptian intellectual achievement», without whose «development Egyptian science, rudimentary as it was, would have taken some other form» [I:xii].

The opening chapter of Section I ('Knowledge') describes «The Fruits of Scribal Activity in Ancient Egypt» [I:1-36, notes 37-46]. Pp. 1-11 deal with the origin of writing and its first uses until the introduction of year names and some kind of rudimentary annaling (keeping track at least of the height of the yearly flooding, important for tax determination) during D.1 (c. 3000 BCE). Then follows a presentation of material that portrays the composition and tasks of the scribal profession and of positions that presupposed scribal skills (including 'lector priest', physician, 'hour watcher', and calculator), and of the various institutions that carried the highest (i.e., most prestigious) levels of scribal knowledge: The 'House of Books', the 'Place of Records' (both mentioned in Old Kingdom sources), and the 'House of Life' (Old Kingdom to Achaemenid or Ptolemaic times). All in all, medicine and magic, astronomy (or 'star gazing'), determination of the time for religious festivals, rituals for sacrifice, and knowledge of gods and temples, turn out to constitute a network; in as far as they were not taken care of by the same person, their specialists worked closely together.

The first document of Section I is the 'Palermo Stone', a D.5 document (c. 2400 BCE) surviving (incompletely) in sundry pieces, the most important of which is now in the Palermo Museum. It contains annals for the first 5 dynasties, and shows how the system of historical registration developed over time: from around the beginnings of D.1, year names are recorded; from some point during the same dynasty, even the yearly Nile height is indicated; during D.2, the biennial census of the Wealth of the Land enters year names; with D.4 (the dynasty of the great pyramids), genuine chronicling registering several memorable events (predominantly but not exclusively religious activities) for each year begins, while on the other hand years are counted and not named individually.

Next follow various documents that illustrate the position, prestige and tasks of high-level officials with a scribal background in the Old Kingdom. One of these is the funerary biography of the early D.4 leading administrator Metjen, in which are included quotations from official documents – which implies that a royal chancery provided with archives was functioning at least since the end of D.3. A tale about wonders at the court of King Cheops, presumably composed during D.12 (1991-1783 BCE), gives occasion to the observations – substantiated also in later sections – that «magic pervaded the whole religious fabric of Egyptian society (at least at its top), [that the] Egyptians attempted to achieve afterlife by means that were fundamentally magical, and further [...] were concerned with preserving the cosmic order by those means» [I:206].²

² One might add that the term translated 'magic' (*ike*) is not only a practice, as magic in our

Two well-known pieces show different aspects of scribal self-consciousness as it was inculcated in Middle and New Kingdom scribal schools. One, on 'Scribal Immortality', emphasizes the fame deriving from scribal knowledge, which survives longer and more certainly than the funerary services of deceased kings – not too far from the conviction of modern scholars that «honor and credit [should be given to predecessors] where they are due». The other, the 'Satire of the trades', emphasizes the social superiority of the scribal craft *among those occupations that were open to common people*. Clagett gives no systematic treatment of the education of scribes; the notes to the latter document together with scattered remarks on Old Kingdom education [I:166, 188] shows, however, that he agrees with the picture presented by Helmuth Brunner and John Baines:³ in the Old Kingdom, sons of high officials might be brought up together with the royal princes, and taught with them; or future scribes might be trained as apprentices on the job; the scribal school as a particular institution is a creation of the Middle Kingdom. The advent of the Middle Kingdom thus marks the transition from 'very restricted' to 'restricted literacy'. Those who want to know more may consult Brunner and Baines.

The final document from section I is an onomasticon, in its own words «excogitated by the scribe of the sacred books in the House of Life, Amenope» [I:247], presumably to be dated in the outgoing D.20, c. 1100 BCE. The list of entities presents itself as a «teaching for clearing the mind, for instruction of the ignorant, and for learning all things that exist, what Ptah created, what Thoth copied down» (*ibid.*) – in part a topos shared with the Rhind mathematical Papyrus, introduced as «Rules for enquiring into nature, and for knowing all that exists, [every] mystery, [...] every secret».⁴ Its over-all order is fairly systematic – entities belonging to heaven, air, water and land; offices and occupations in the other world (god, goddess, blessed dead) and the Egyptian court and state; classes of human beings; towns of Egypt; buildings, their parts, and associated types of land; agricultural land and products; etc. Within these groups, however, the progress is often by association rather than by category, as pointed out in Clagett's notes. In view of the prominent place which the use of lists occupies in discussion of the relation between oral and literate culture,⁵ it is worth pointing out that this

understanding, but also a *substance* of which the magician may be 'full' [e.g., I:335]; in the latter connection, an understanding close to 'mana' is warranted.

³ H. BRUNNER, *Altägyptische Erziehung*, Wiesbaden, Otto Harrassowitz, 1957; J. BAINES, *Literacy, Social Organization, and the Archaeological Record: The Case of Early Egypt*, in *State and Society. The Emergence and Development of Social Hierarchy and Political Centralization*, ed. by J. Gledhill, B. Bender, M.T. Larsen (One World Archaeology, 4), London, Unwin Hyman, 1988, pp. 192-214.

⁴ Trans. T.E. PEET, *The Rhind Mathematical Papyrus, British Museum 10057 and 10058*, London, University Press of Liverpool, 1923, p. 33.

⁵ See J. GOODY, *The Domestication of the Savage Mind*, Cambridge, Cambridge University Press, 1977, pp. 74-111. Pp. 99-103 discuss the Egyptian onomastica.

Egyptian list is thus very different in character from the lists that constituted the backbone of proto-literate (and later) Mesopotamian scribal education; from the earliest beginning, these were ordered by category; they would never put one type of land in a list together with parts of buildings, and another together with vegetables and grain. In terms of Luria's distinction between 'categorical classification' and 'situational thinking',⁶ the Mesopotamian lists are of the former type – the type which Luria found in Soviet Central Asia in the 1930s to be characteristic of kholkos activists, those engaged in the construction of modern society; Amenope's catalogue of the world, on the other hand, comes closer to the latter variety – characteristic of the illiterate peasants who knew which kind of land and which products belonged invariably together in their traditional world.⁷ This character of Amenope's (and other) Egyptian lists agrees well with an observation made by Clagett [I:239], *viz* that they correspond to Ptah's creation of the existing world by the spoken word, not only according to the somewhat later 'Memphite theology' but also to that part of Amenope's introduction that does not repeat the commonplace of the Rhind Mathematical Papyrus: what Thoth the divine scribe copies down will be words that create, not things created. Just as much as a lexicon, the onomasticon is a ritual reenactment of that creation. No similar idea seems ever to have been entertained by the creators of the Mesopotamian script.

The same intertwinement of description with magic and religion recurs as the constant theme of section II, 'Order'. In Clagett's words, «during the three thousand years of Pharaonic Egypt there was no natural philosophy or physics that was separate from religion, myth, and magic» [I:263]. To the opinion of certain Egyptologist (exemplified by P. Derchain, but the stance is not his alone) that the religion of the Egyptians – considered eminently practical people – was «no mysticism but physics» it is retorted that the 'physics' in question is «unlike any physics for which we now customarily use the term, since it regularly included contradictory symbols to represent natural entities and events, expressed contending forces by conflicting gods, made wholesale use of divine agencies to describe creative acts, and everywhere employed magical terms and pronouncements to bring things into existence and to effect communication between human and divine beings» [I:373]. That contradiction is not an artefact produced by the modern compression of conflicting creeds

⁶ A.R. LURIA, *Cognitive Development. Its Cultural and Social Foundations*, Cambridge, Mass., & London, Harvard University Press, 1976 (1st ed. Moscow, Nauka, 1974), pp. 48ff.

⁷ John Wilson explains this hybrid character of the Egyptian lists by seeing them as a kind of cargo cult, «probably an adaptation by ignorant Egyptians of what they thought to be lexicography over in Asia. They thought that just memorizing the writings of these things in categories had something to do with knowing and classifying phenomena» – discussion contribution in *City Invincible*, ed. by C. Kraeling, R. McC. Adams, Chicago, University of Chicago Press, 1960, p. 104.

into a single 'Egyptian cosmology' becomes clear in a passage from the Memphite Theology (document II.9, [I:600]): «[Ptah's] Ennead is before him as the semen and hands of Atum, for [it is said that] the Ennead of Atum came into being by means of his semen and his fingers. But the Ennead [of Ptah] is the teeth and lips in this mouth which pronounced the name of everything [...] and which gave birth to the Ennead»: the Ennead, indeed, is *the same set* of nine gods in both cases; it may well, at the same time, be the product of Atum's masturbation and result from Ptah's creative word, just as *every* major temple may stand on the first spot of firm land that emerged from the primeval waters. According to Tertullian's criterion (*credo quia absurdum*) these are clearly mystical (or poetical) truths, to be judged not according to their immediate meaning but from their contribution to producing a meaningful life-world.

A fairly long passage in Chapter II [I:268-279] is devoted to interpretations of this situation where «all the concepts were accepted to be valid by the same theologians» (Rudolf Anthes, quoted p. 271). Apart from Anthes (who sees the contradictory explanations as symbolic explanations of that which cannot be «understood directly by means of reason and sensual experience» – p. 272), most writers have been astonishingly blind to the character of religion in their own culture.⁸ Instead of inventing a 'mythopoeic' mode of thought which should characterize the ancient Egyptian (and Mesopotamian) culture *in general* (Henry Frankfort) or a «many-valued logic» (Hornung),⁹ Clagett's down-to-earth-position is certainly more appropriate: that the only branch of Egyptian thought where something like natural *philosophy* – reflection on the fundamentals of natural phenomena – occurs is that of religion. That did not prevent the Egyptian scribal officials from having a very 'western' view of the link between measurable Nile height and possible taxation level.

Chapter II [I:263-372, notes 373-406] describes the various cosmogonies connected to various main temples – On/Heliopolis, Khmun/Hermopolis, Memphis, Thebes (the New Kingdom Amon-Re cosmogony) – together with the monotheistic Aten cosmogony and the cosmogonies from the Roman period (temple of Esna). Differences and temporal development are pointed out, but also the existence of a set of fundamental ideas that run through all the different narratives – the existence before creation of an amorphous 'Abyss' of primeval waters, from which a creator god (or corporation of eight

⁸ According to E. Hornung, quoted p. 273, «the principles of western logic» would consider it «an impossible contradiction for the divine to appear to the believer as one and almost absolute, and then again as a bewildering multiplicity»; true enough, of course, when Muslim theology or Enlightenment Deism applies «the principles of western logic» to Trinity.

⁹ As one might perhaps guess, Hornung uses the notion of logical polyvalency as a poetical metaphor (probably without knowing so), and not according to its technical meaning – e.g., that the god whom I address in this very moment is «superior to the gods, he is more than they are». But in this sense, «many-valued logic» is as 'western' as binary logic, one being the preserve of the theological faculty (and poetry) and the other of the philosophical faculty.

gods) first fashions his own form and makes land emerge, and then goes on with the creation of other gods (by spitting, by masturbation, by speaking, on the pottery-wheel, by craftwork) and the world in general with its inhabitants and its order (*maat*). As observed by Clagett [I:265f], this imagery reflects «the two pervading natural features of Egypt: the overwhelming importance of the Nile and its annual flooding and the ever-present sun as a continuing source of light and heat». Also recurrent is the idea that abysmal chaos is not suppressed but only pushed back, and that it remains an ever-present threat which (at least in some versions) is eventually going to engulf the ordered world.

The last part of the chapter deals with 'cosmology', with «what kind of world resulted [from creation], what sort of visible and invisible beings populated this world, and what was the nature of the forces which were believed to keep the world and its parts functioning harmoniously and of those which were dangerous and threatened the desired harmony of the cosmos» [I:328] – with the nature of the gods (including their possible historical origin in fetishes and animal forms – but only ambiguous iconographic evidence for such a process exists); with the relation between gods and magic (a substance or 'magical force', we remember, not only a powerful practice); with the question of human immortality and the topography of the Netherworld (not yet exclusively 'nether' in the Old Kingdom); with the position of the king between gods and ordinary humans; with the interpretation of dreams through semantic analogy, or contrast, but also through phonological similarity or punning – no innocent amusement but another aspect of the power of the creative word.

The documents that constitute the second part of Section II provide the general exposition with concrete body and substance, even though, as Clagett observes in his introduction to the 'Coffin texts' [I:435], «it is obvious that I have only skimmed the cosmogonic and cosmological ideas from this extensive collection and the reader will certainly find further study of it of great profit if he wishes to gain further knowledge of ancient Egyptian religious thought». They illustrate not only the relation between continuity and change regarding the ideas that are expressed but also the developments of intellectual style. The earliest texts, the 'Pyramid Texts' (Document II.1) from the royal tombs of late D.5 and D.6 (2350-2180 BCE) are «collections of individual statements or spells», presenting themselves as «Words to be Spoken», with «no overall coherence and no single, all-embracing title. They reflect spells used in burial and offering rituals, and their oral character is everywhere evident» [I:407f]. The 'Coffin Texts' (Document II.2), written inside the coffins of nobles from the late Old and the Middle Kingdom, are not very different in character as far as the spells themselves are concerned; the Middle Kingdom specimens, however, start giving titles to the single spells, often written in red ink [I:433f,455]; orality is clearly on the wane after the establishment of the school institution and the concomitant shift from 'very restricted' to 'restricted literacy'.

The Coffin Texts reflect what has been spoken of as a 'democratization' of

Egyptian religion at the end of the Old Kingdom, after which even common mortals and not only the king were allowed identification with the resurrected Osiris. Clagett rightly considers the term extravagant [I:430]: those who procured for themselves the right to immortality were not commoners but those same nobles who had seized effective power and confiscated royal benefits in the breakdown of Old Kingdom centralization. (In the long run, it is true, what started as a narrowly oligarchic revolution spread to somewhat broader circles).

The so-called *Book of the Dead* (Document II.3, early New Kingdom and onwards), various collections of «Spells for going forth by day» (i.e., for allowing «the deceased to leave the tomb in any form in which he wished to leave it» – [I:451]) still contain much material that goes back to the early collections. The literate character of the texts, however, becomes even more obvious. Not only have red-ink titles become the rule: as behoves a scholarly tradition, the spells are amply provided with explanatory scholia; what emerged as a technical tool has achieved the character of theological *theory*, while still retaining its instrumental function (as strikingly revealed by the presence of a spell that shall prevent the ‘heart’ or bad conscience of the deceased to betray him when confronted with Osiris the great Judge [I:458]).

This character of theological or cosmological treatises is even more outspoken in other New Kingdom texts like the *Book of Amduat* (the Netherworld), the *Litany of Re* and the *Book of the Divine Cow* (Documents II.4-6) and in the ‘Memphite Theology’ (Document II.9), an archaizing work known in a copy from c. 700 BCE and probably not much earlier (in any case not earlier than mid-New Kingdom). Whereas the ‘chest of writings’ brought to the scene when the D.5 Vizier Washptah fell suddenly ill (Document I.4) is likely to have contained casuistic medical papyri and spells to be used by the lector-priest (summoned by the King together with the chief physician), the New Kingdom and later House of Life is likely to have possessed such descriptive or eschatological works along with the magical evergreens and hymns (an intermediate category from this point of view – even they only become ‘literature’ when oral culture is waning).¹⁰

Astronomy, which was deliberately left out from cosmology as considered in Section II, is treated together with calendars and clocks (long- and short-term

¹⁰ A selection of hymns constitute Document II.7; Documents II.8 and II.11 are excerpted from texts that reflect the continuing popularity of spells and magic (the 4th c. BCE *Book of Knowing the Creations of Re and the Felling of Apep*, and the New Kingdom ‘Harris Magical Papyrus’). The former excerpt, however, is essentially a piece of descriptive theology, while the latter consists of hymns.

The Mesopotamian record provides an interesting parallel to the Egyptian literarization of hymns: hymns (and proverbs) are written down for the first time in the Fara period (26th c. BCE), precisely when scribes turn up in the sources as a particular (and very self-conscious) craft distinct from the managers of temple estates, at the turn from ‘very restricted’ to ‘restricted literacy’.

time-keeping) in Section III (= Volume Two). Indeed, the only apparently astronomical element of the cosmologies – the description of the stations of the nocturnal voyage of the Sun-god Re through the Netherworld in the *Book of Amduat* – is not only devoid of concrete astronomical detail but also in a curious contrast to ‘more astronomical’ ideas about this nocturnal voyage (see below).

Section III (introduced by Chapter III, [II:1-129, notes 131-165]) thus brings us to the heart of what would normally be considered Egyptian ‘science’, starting with the intricate question of calendars. Well-known is the civil calendar with a year of 12 months of 30 days each (subdivided into three ten-day ‘weeks’) and 5 extra epagomenal days – 365 days in total; almost as familiar is the notion that it was originally geared to the heliacal rising of Sirius (Egyptian ‘Sothis’), and therefore begun in 4241-4238 BCE or 2781-2778 BCE (1321-1318 BCE being obviously too late)¹¹ – throughout the Pharaonic period, the ‘Sothic year’ determined by this heliacal rising remained very close to 365.25 days, for which reason the appearance of Sirius is delayed by one day every four years with regard to the civil calendar (so, approximately, are the yearly flooding and the seasons). Clagett presents the whole discussion since Eduard Meyer exposed the details of the calendar in 1904 and opted (in agreement with the accepted Egyptian chronology of his times) for the earliest date. Clagett espouses Neugebauer’s arguments [II:31f]:¹² Observations made over a single year will reveal that an astronomical, i.e., lunar, month is 29 days as often as 30, and the observations of 40 years will demonstrate these to fall 10 days short of the Sirius rising; measured with an astronomical gauge, the civil year is so crude that this cannot be its origin. If the origin is agricultural, however, 365 days will result automatically from averaging over a couple of decades the time between successive Nile floodings; on the other hand, only observation of this quite irregular phenomenon made over several centuries would allow significantly higher precision. Even the structure of three seasons (‘inundation’ – ‘emergence [of agricultural land, and sowing]’ – ‘low water/harvest’) is obviously agricultural in reference and highly unlikely to be astronomical in origin (if fitted to one solstice or equinox, any uniform three-season scheme will by necessity miss the other). The year of 365 days and an administrative month of 30 days are likely to have been adopted around the beginning of D.1

¹¹ B. GRUN, *The Time-Tables of History*, London, Thames and Hudson, 1975, indeed tells 4241 BCE to be «the first exactly dated year in history» on this account!

¹² Since Meyer’s version is still widely accepted outside the circle of narrow specialists, they deserve to be repeated. Neugebauer’s full discussion is found in *Die Bedeutungslosigkeit der ‘Sothisperiode’ für die älteste ägyptische Chronologie*, «Acta Orientalia», XVII, 1938, pp. 169-195, and *The Origin of the Egyptian calendar*, «Journal of Near Eastern Studies», I, 1942, pp. 396-403; both are reprinted in O. NEUGEBAUER, *Astronomy and History*, New York, Springer, 1983, pp. 169-203.

(around or slightly before 3000 BCE), the former in the belief that it fitted the agricultural year; as the discrepancy between the behaviour of the Nile and this year became too obvious, the Sothis rising as harbinger of the flooding was introduced as the official beginning of the year around 2780 BCE, and remained so in terminology even when obviously not so in fact. Since the earliest plausible evidence for the use of a year of exactly 365 days is from late D.4 (c. 2470 BCE) and the earliest definite proofs from early D.5 (c. 2440 BCE) [II:28f], «to be certain about these conclusions would be foolhardy, since we have piled conjecture upon conjecture» [II:33].¹³

As a parallel showing that a 30-days month introduced for administrative purposes is conceivable, Neugebauer pointed to the later practice of Babylonia. It is worth adding that this Mesopotamian administrative month, kept well apart from the normal lunar month, has now been followed back to the Jemdet Nasr period, i.e., to the late fourth millennium BCE.¹⁴ This is exactly the phase where elements of Mesopotamian culture (certain characteristic artistic motifs, certain features of temple architecture, perhaps some basic ideas about writing that served the development of extant Egyptian marks into a rudimentary script) and even some Mesopotamian artefacts (cylinder seals, ceramic vessels) turn up in Egypt.¹⁵ Administrative needs being perhaps analogous,¹⁶ independent 'invention' of a counterfactual month remains a possibility; but the possibility of borrowing from a culture with which D.1 Egypt was in demonstrable contact supports Neugebauer's idea.

Older than the civil calendar is a lunar calendar, whose traces are found in the sequences of temple festivals, and which remained in use as liturgical year.

¹³ A postscript, «A Petroglyph Discovered at Nekhen with Possible Astronomical Significance» [II:497-506], contains a paper by James O. Mills about a probably Predynastic graffito from upper Egypt. Along with other marks, a number incisions arranged in an arc might (thus Mills) record the changing direction of sunset or sunrise; if the rock in which the graffito is encased has been rotated by some 10°, one of the extreme incisions was originally in the direction of winter solstice sunset; Mills asserts (with Clagett's polite consent) that this would constitute evidence that the Predynastic Egyptians knew about the 365 days' year; the reviewer would object, firstly, that Neugebauer's argument against an astronomical origin of this year holds even in this case; secondly, that no necessary (nor just plausible) link exists between the observation of extreme azimuths and the counting of days. Azimuth observations, heliacal risings and similar phenomena are in fact *alternatives* that allow cultures without a fixed calendar to predict the arrival of the new season. Thus, e.g., Hesiod, *Works and days*, verse 383f, in HÉSIODE, *Théogonie. Les Travaux et les jours*, Le Bouclier, ed., trans. by Paul Mazon, Paris, Les Belles Lettres, 1928, p. 100.

¹⁴ See R.K. ENGLUND, *Administrative Timekeeping in Ancient Mesopotamia*, «Journal of the Economic and Social History of the Orient», XXXI, 1988, pp. 121-185.

¹⁵ B.G. TRIGGER, *The Rise of Egyptian Civilization*, in B. G. TRIGGER et al., *Ancient Egypt. A Social History*, Cambridge, Cambridge University Press, 1983, pp. 1-70, here pp. 36f.

¹⁶ «Perhaps analogous», but hardly the same. In proto-literate Mesopotamia, the 30-days calendar was used to determine fodder rations for animals (and workers?) within a highly bureaucratic economy; the biennial «counting of the Wealth of the Land» (introduced moreover during D.2, it seems) suggests nothing similar.

According to Richard A. Parker, it intercalated an extra month in the year whenever the Sothic rising took place within the last 11 days of the year; Clagett scrutinizes the sources on which this elaborate theory is built, and concludes «that Parker's opinion that the old lunar calendar was intercalary may be correct (though not certainly so), but that (1) the use of the Sothic heliacal rising, that (2) the intercalary month (if it existed) was named 'Thoth,' and that (3) the lunar calendar in schematized form is that given in the Ebers calendar and in the astronomical ceilings of Senmut's tomb and the Ramesseum¹⁷ – are all unproved and indeed untenable» [II:21f].

A later lunar calendar is described in a papyrus from 144 CE or later (P. Carlsberg 9); as Clagett quotes Parker, it is «the only truly mathematical astronomical Egyptian text yet published» [II:23f].¹⁸ The papyrus is translated and further discussed as Document III.9; it describes a 25 years' intercalation cycle, which makes the lunar year agree with the Egyptian civil year with an error of only 1 day in c. 500 years. As it turns out, the most likely time for the construction of the cycle is 357 BCE. It thus antedates the Macedonian conquest and the establishment of Hellenistic scientists in Egypt; the basic idea is likely to have been borrowed from Babylonia (Egypt was under Achaemenid rule from 525 to 404 BCE, and again from 343 to 332 BCE), and schematic intercalation was used in Babylonia well before that), but the terminology of the scheme is purely Egyptian and thus evidence that the idea was fully naturalized. Only Egyptians (not even foreign conquerors of Egypt) are also likely to have encountered the problem of fitting together the Egyptian liturgical year and the Egyptian civil year.

The last year treated in the volume is a conjecture: the fixed Sothic year of 365.25 days, which in the opinion of many Egyptologists must have been known to and used by the Egyptians. Clagett discusses the purported evidence (much of it is in Documents III.2 and III.10), and argues convincingly that ability to predict when the actual Sothic rising would take place in a given year (almost self-evident, and well documented though with unknown precision since the Middle Kingdom) does not entail the use of a corresponding year; nor does the wording of the 'Decree of Canopus' [II:326-329], an abortive attempt to change the length of the civil year into 365.25 days, suggest that such a calendar already existed.

Clocks are of three very different kinds: star clocks, water clocks, and

¹⁷ The Ebers Calendar and the astronomical ceilings are among the documents translated and discussed later in the volume.

¹⁸ Evidently, this assertion is only true if 'Egyptian' means «in the tradition of Pharaonic Egypt», allowing us to exclude not only the *Almagest* but also material of purely Babylonian origin; but this exclusion remains Clagett's sensible choice, which also allows him to leave out the late astrological texts, mainly based as they are on Greco-Babylonian syncretism – cf. [II:129].

sundials. Star clocks can be followed from D.9-10, and are likely to be an Old Kingdom invention – they are rendered though defectively on coffin lids, and the underlying system has been deciphered by Neugebauer and Parker. In the D.9-12 version, they make use of a set of stars or groups of stars (the ‘decans’) whose heliacal risings fall in the beginning of the 36 ‘weeks’ of the civil calendar (with some further complication due to the epagomenal days, and an automatic outdating because of the discrepancy between the civil and the sidereal year); *if* all decans had had the same latitude (which was not the case), their longitudes would thus differ by c. 10°. The first hour lasted from the beginning of complete darkness to the next rise of a decan; the following ten hours were marked by successive decanal risings; the remaining time to the beginning of dusk counted as a twelfth hour. At the beginning of a ‘week’, the first 11 hours would thus be approximately equal; around summer solstice, even the twelfth hour would not be very different at the first day of a ‘week’; around winter solstice, it would be very much longer (and obviously so even to an Egyptian stargazer, who would observe the rise of several extra decans); the ‘hours’ of the Old Kingdom night were thus neither seasonal hours nor equinoctial hours, nor were they meant to be equal divisions of the period of darkness of the actual night; they marked stations of the Sun during its nocturnal voyage through the Netherworld, and constituted no metrology. Correspondingly, ‘hours’ were originally only divisions of the night (corresponding, we may assume, to particular liturgical duties);¹⁹ only later would the day be divided by analogy in its own 12 hours [II:49].

That the copies of the decanal clocks on coffin lids are imperfect is cogently explained by Clagett by their funeral purpose: these ‘clocks’ were not actual aids for observation but symbolic [II:56]. The acceptance of unequal hours may be seen in the same light: if certain acts had to be performed at ‘hours’ defined by the rise of decans, equal division would be a pointless and pedantic *Verschlimmbesserung*. Within the religious sphere, truth is symbolic and hence a matter of acceptance and consensus. This is beautifully illustrated by the *qiblah* (prayer direction and orientation of mosques, supposedly the direction toward Mecca) used in Medieval Islam: in Samarqand, for instance, one legal school would pray toward the south, another toward the west²⁰ – both in evident disagreement with the ‘scientific’ truth as perfectly known by the astronomers and mathematicians of the time. Islam had no *need* for mathematicians who might determine the astronomically correct prayer direction (*pace* numerous historians of mathematics); but Islam might serve as a pretext for mathematicians like al-Khwārizmī who wanted to be useful to

¹⁹ The earliest extant description of the duties of the stargazer tells these to be «attending to the guiding (or introduction) of festivals and giving all people their hours» (6th c. BCE, quoted [II:491]).

²⁰ D.A. KING, *Astronomical Alignments in Medieval Islamic Religious Architecture*, «Annals of the New York Academy of Sciences», CCCLXXXV, 1982, pp. 303-312, here p. 305.

their community. There is thus no reason to be astonished by that lack of care for horological precision which Clagett shows to persist until the end (without being astonished), nor *a fortiori* to be scandalized as Ludwig Borchardt in what Clagett characterizes as a «patronizing and distasteful remark» [II:423] about the Egyptian failure to understand that time is money. The interesting problem is rather to understand why a certain interest in precision did develop after all; professionalization of stargazer priests (‘hour-watchers’, as they were called until Ptolemaic times – [II:58]) and their environment seems to be the answer (cf. below on Amenemhet), rather than technological needs like the determination of working time (as seen in late third millennium Mesopotamia).

A first adjustment seems to have taken place during late D.12 [II:56]. At that moment the original decan system will have gone so much out of phase that many decans may have been invisible during the month where they were meant to ‘work’; revision in this situation will have been compulsory even for religious purposes. At the same time, however, a rather different system had developed, making use of meridian transits instead of heliacal risings; because of the different latitude of the old decans, most of the decans had to be, and were indeed replaced: stars whose heliacal risings differ by 10 days (or whose risings during the same night differ by 40 minutes) may well culminate at the same time, perhaps even in reverse order. The introduction of this new system thus represents a fairly radical break with the tradition, and presupposes the construction of a new canon based on fresh observations. The same holds for the ‘Ramesside star clock’ depicted in royal tombs from D.19 but apparently constructed around 1470 BCE. Here, the year is divided into half-months instead of ‘weeks’; the beginning of each hour is determined by the passage of a particular star over one of seven lines, of which the central one is the meridian.²¹ The whole period of darkness is thus, it seems, meant to be divided equally and with fair precision (as far as it could be calibrated by means of a water clock, we may assume). Once again the inherited system is thus broken up and reorganized empirically.

By 1470 BCE, outflow water clocks were already well-known, and they are likely to have been used for calibrating the Ramesside star clock. Like the Babylonian water clocks, the early Egyptian specimens are of the outflow type;

²¹ The ‘seven lines’ is an interpretation though supported by the drawn diagrams: the verbal text tells that the star is «on the left shoulder», «on the left ear», «opposite the heart» [i.e., central], etc. There has been some discussion of the actual technique – whether a string frame was used or the stargazer was actually confronting a partner (or a statue); both possibilities are suggested by the tomb copies of the clocks [Fig. III.19a-b]; a third interpretation, proposed by E. M. Bruins, is analyzed [II:145f] and in the end characterized as «surely [...] a perverse theory».

It may be added that the Egyptian ‘canonical system’ for representing the human body (etc.) made essential and standardized use of square grids – cf. E. IVERSEN, *Canon and Proportion in Egyptian Art*, Warminster, England, Aris & Phillips, 1975² (1955¹). In itself, metaphorical use of parts of the human body for their positions within a grid is thus not excluded.

but whereas the Babylonian clocks measured the weight of water that had flown out (which would permit a periodical refilling in order to keep the water level approximately constant – whether it was done we do not know), the Egyptian specimens measure the water level; in order to compensate for the decrease of the outflow with decreasing water height, they were shaped as inverted truncated cones ('flower pots'), and not meant to run empty – one, found in Karnak and constructed in the early 14th c. BCE, is discussed in detail [II:66ff] and depicted. Clagett, following earlier workers, discusses whether its slope is optimal and concludes with Borchardt from the mathematical model used in all discussions of ancient water clocks that the walls should have been somewhat steeper [II:76]. As a run-away physicist, the reviewer will observe that this model presupposes that energy losses due to surface tension and the effects of friction and adhesion can be neglected; surface tension and adhesion are relatively unimportant as long as the water leaves in a jet, but then friction is influential; when dripping starts (as it does in the Karnak clock, see [II:69]), surface tension will slow down the outflow significantly, to an extent that depends on adhesion effects and the actual geometry of the orifice;²² only empirical tests can decide whether the Egyptian clock was better than the one proposed by the mathematical model.²³

The Karnak clock contains several scales corresponding to months with nights of different lengths; the month names on the scales are about one month off, which means that the clock was copied from an earlier specimen from around 1500 BCE. This date corresponds to a very interesting text included as Document III.15: the funerary autobiography of Amenemhet, a high official of the late 16th c. BCE who, «while reading in all of the books of the divine word» found that the longest night was 14 if the shortest was 12 hours [II:459]; Clagett suggests in a note that the 14 be understood as 'fingers' in a water clock and not as a number of some universal time unit – certainly justified, since even the winter night is divided into 12 hours in the corresponding water clocks. He also tells of having constructed a water clock with corresponding scales in honour of King Amenhotep I – «Never was made the like of it since the beginning of time». The somewhat opaque final passage seems to claim that it was precise for all seasons. As mentioned above, «never ... since the beginning of time» was a commonplace, and therefore not necessarily to be taken to the letter; nor is it quite clear how much of

²² See J. HØYRUP, *A Note on Water Clocks and on the Authority of Texts*, «Archiv für Orientforschung», XLIV-XLV, 1997-98, pp. 192-194.

²³ To the objection that this is unlikely or would at best be accidental, since the Egyptians «had no means of determining whether their hours were equal or not» (R.W. Sloley, quoted [II:70], but an oft-repeated claim) it may be replied that they had: another water clock which was refilled after the lapse of one hour. Whether the interest of some clock builder in precision was large enough to inspire this idea is a different question.

Amenemhet's discovery was made in books and on the scales of existing water clocks and how much by his own observation; in any case it is obvious that the construction of a water clock at least as precise as anything known so far was an object of pride, and that the clock itself was worth being offered to the king; since the text still speaks of night hours only, inspiration from non-liturgical (or non-astronomical) time measurement seems absent.

The Karnak clock assumes the change of the length of night to be uniform from solstice to solstice – in the idiom used to discuss Babylonian astronomy, it constitutes a zigzag-function (which should *not* be taken as evidence of a borrowing, cf. note 26). Fragments of clocks from the Hellenistic period shows that the quest for increasing regularization continued [II:73f]: they put the shortest night at 11, the equinoctial night at 12 and the longest at 13, and make the increases and not the lengths follow a zigzag function; this is a second-order approximation and should be better – but since the true ratio is rather 14:10, the method behind the supposed improvement is obviously bookish – a 'rational reconstruction' – and not empirical.

A papyrus from Oxyrynchus (third c. CE) reveals something about the kind of 'books' that are likely to have inspired this reconstruction [II:75f]. It computes the volumes of water corresponding to successive hours; for this it assumes the volume of a truncated cone to be the mid-cross-section times the height; the area of a circle to be $\frac{1}{4} \times \text{arc} \times \text{diameter}$; and the arc to be 3 diameters. All three formulae are used in that Near Eastern practitioners tradition which is reflected in the practical geometry of the Old Babylonian school; taken singly, each of the three formulae would prove nothing; but their occurrence together leaves no reasonable doubt about the inspiration for the computation.

During the Hellenistic period, inflow water clocks also begin to turn up;²⁴ once again, they should be better in theory than the outflow type, and may have been believed to be so, since they provide the obvious answer to the problem of unequal flow of which the Egyptians were demonstrably aware. Once again, however, no real improvement is obtained [II:78f]; firstly, the old 14:12 ratio is conserved; secondly, the only preserved specimen has misunderstood the zigzag principle and makes the increases follow an inverse zigzag-function.

Daytime, originally including twilights, was divided by analogy into 12 hours, which were measured by two types of instruments. So-called shadow clocks may be referred to already in a Middle Kingdom text, but the oldest specimen is from c. 1450 BCE. They measure the length of the shadow, more precisely the east-west component of that shadow.²⁵ A description from c. 1300 BCE (Document III.16,

²⁴ Clagett analyses the interpretation of a temple decoration purportedly indicating the use of inflow clocks already during D.18 (mid-second millennium BCE) and shows that it is «entirely fanciful» [II:82f].

²⁵ Other types were developed in the late period [II:93-95].

[II:465f], cf. [II:84f]) shows that the division points of the scale are found by means of a mathematical construction, not empirically (their distances decrease uniformly).²⁶ Nothing in the description nor in the incomplete specimens that have been found suggests a correction for the changing length of the day. Nor was there any obvious need for such a correction – with four marks before noon and four after noon the model would automatically ensure that the day had 12 hours; one before sunrise, one between sunrise and the first mark, etc. Clagett describes how the model could be equipped so as to produce equal hours [II:91] by means of a device suggested by Borchardt. He comments, however, that one «cannot emphasize too strongly [...] that there is no actual evidence that such a bevelled crossbar was used, and I suspect that the apparent indifference of the ancient Egyptians to the exact divisions into equal hours of any of their clocks makes their use of this device unlikely»;²⁷ he has more immediate sympathy for a device by which Bruins would take the seasonal variation of the solar height into consideration, but points out that «this is the most coherent of the translations but is the one which has been most widely altered from what can be read in the text», and politely «remind[s] the reader that it is not always prudent to correct the text to fit the reader's fancy» [II:467].

Sundials, registering the direction of the shadow of a horizontal gnomon on a vertical surface, can equally be traced to the New Kingdom, the oldest specimen being from c. 1220 BCE. In this piece, the angles between hour lines change so irregularly that it is not even worth discussing whether it attempted to measure equal hours – but like the shadow clocks, the model ensures that the day (here, from sunrise to sunset, since such are the divisions) would always be of 12 hours. An apparently Hellenistic specimen (with the Egyptian month names given in Greek) is precise enough to allow analysis, and reveals itself to be another a-priori construction – whatever the season, morning and evening hours are too long, and noon hours too short, as shown in a drawing borrowed from Borchardt [Fig. III.57].

As pointed out by Clagett [II:98], the many attempts at improvement and apparent systematization – to which comes also attempts to describe the changing lengths of day and night in terms of a scheme of 24 equal hours [II:98-106] – did not entail any theoretical unification; apart from the probable use of water clocks to calibrate the Ramesside star clock, no use seems to have been made of the fact that the different devices measured the same thing (as

²⁶ That is, they follow a zigzag function, and the positions themselves thus the summation of such a functions; there is hence no need whatsoever to ascribe the use of second-order approximations in the Hellenistic water clocks to Mesopotamian inspiration.

²⁷ The reviewer's immediate impression was that Borchardt's invention was of kind that might be expected in 18th-c. (CE!) instrument making: ingenious yet simple, and in need of trigonometric calibration.

revealed by the independent a-priori constructions used in the different techniques). In an ad-hoc distinction, we may say that progress was mainly *technological* in character (as cars, railways and airplanes may be improved independently of each other, even though all provide transportation), not oriented toward *theoretical unification* into a single coherent metrology. It is characteristic that a 3d-c. BCE description of the duties of an astronomer (document III.18) still specifies that he is «one who divides the hours of the two times» (i.e., day as well as night) [II:495].

Astronomy is the last topic of Volume Two, which more specifically deals with the description of the heaven and the ideas about the movement of the stars when they were invisible. In agreement with this, Clagett often reminds the reader that an Egyptian 'astronomer' was actually a 'stargazer'. The main material, apart from the decanal clocks, is constituted by the astronomical ceilings of tombs and ceilings and similar documents, where the «arrangement of the various astronomical elements developed into an almost standard form that we can with some looseness call the Ancient Egyptian Celestial Diagram» while recognizing that «there are about six families of the standard form» [II:108]. To this standard diagram comes from 200 BCE onwards rectangular, elliptic and circular zodiacs, in which elements of Greco-Babylonian and direct Babylonian origin are integrated with traditional Egyptian constellations and with yet another kind of decans, which have lost any actual function and «represent the deities of the dual year, the combined lunar-civil year» (Neugebauer & Parker, quoted [II:476]).²⁸

The star diagrams are, precisely, diagrams and not maps; as Clagett formulates (observing that the Zodiacs are not even genuine diagrams but decorative and reverential), they are «elements that would be astronomically useful to the deceased in his life in the Otherworld» [II:479], collecting the timetelling decanal stars in one half of the ceiling and the useless circumpolar constellations in the other. But no faithfulness was aimed at (nor achieved!) that would allow us to identify more than a few of the stars they contain.

One of the theological treatises of Section II, we remember, told the nocturnal voyage of the sungod Re through that Otherworld which after the Old Kingdom became a Netherworld only. The description of the transit decanal clock contained in the *Book of Nut* (Document III.12, cf. [II:57f]) and the 'dramatic text' in Seti I's cenotaph (Document III.13) also tell that the decanal stars, like Sirius, spend 70 days in the Netherworld (the time where they are below the horizon during night, as we would say); then, for 80 days,

²⁸ They are thus not identical with the 'decans' that entered Greek and later astrology, which are 10°-divisions of the Zodiacal signs.

they rise before dawn but do not culminate before coming invisible; during the ensuing 120 days they 'work', i.e., serve to mark the hour by their culmination. During 90 days they have already culminated before sunset; when these are finished, they die again and go the Netherworld.

This might seem, if not 'modern' then at least 'Ptolemaic' – the Sun and the stars pass the visible heaven and then go below the Earth; but this is a misunderstanding, as explained in the 'dramatic text': the stars go to the Netherworld as other persons who die; but they do so for 70 consecutive days, not every night. And the heaven, of course, is no sphere surrounding the Earth but the Goddess Nut standing on her hands and feet, head toward the west and hind part in the east, a «sow who eats her piglets» [II:399]. This name she has deserved because she swallows the Sun and the setting stars, who then pass through her body (*above* their visible path) and are reborn in the east. Clagett tells [II:396] that he has included this text, «essentially mythological in character and content» and lacking «all but trivial astronomical detail», «in a volume devoted largely to technical detail» in order to underline once more that «such scientific knowledge that the ancient Egyptians acquired was presented integrally with religion, myth, and magic», and that «that knowledge has been transmitted to us almost exclusively in religious documents». We may add that the very content of the document, the topographic visualization of the movement of the heavenly bodies, shows that there was no easy transformation of this world picture into one presupposing a heavenly sphere. The Egyptian star diagrams fit their topographical imagination; star maps as we know them from the Ptolemaic Middle Ages (not to speak of star globes) are meaningless in this context.

In conclusion we may observe that Clagett has produced two rich volumes which differ from much history of Egyptian science by taking Egyptology seriously, as an integrated study of Egyptian culture. But their fundamental approach also differs from that of much Egyptology in a way that can only please a historian. In the words of a group of highly informed insiders,

Ancient Egypt has proved remarkably resistant to the writing of history which is not traditional in character; which is not, in other words, concerned primarily with the ordering of kings and the chronicling of their deeds. [...] For one thing, the very completeness of the chronological listing of kings which several generations of modern scholars have given us creates an image of knowledge in detail which other kinds of evidence cannot match. The abundance of royal art and architecture compounds the problem with an illusion of familiarity.²⁹

²⁹ B.G. TRIGGER et al, *Ancient Egypt*, cit., p. XI (note 15).

This illusion of familiarity reflects itself in the «default theory» that everything whose later origin cannot be demonstrated will go back at least to the early Old Kingdom. In one recent formulation,

Il convient de rappeler que ce que l'on connaissait au Moyen Empire était un savoir élaborée bien avant, probablement dès le début de l'Ancien Empire. Ce savoir vénérable se retrouve intact pendant toute l'histoire égyptienne, jusque dans les papyrus grecs de l'époque byzantine, sans changement ni amélioration notables, comme le prouve le papyrus d'Akhmim.³⁰

Without being polemical, Clagett points to several instances of this same perennializing presupposition – e.g. [I:495f] when it was concluded from the unspecific words of the D.25 'Memphite Theology' (*viz* that it was copied from a worm-eaten original) that the original composition «was written either in Archaic times or at least no later than the Old Kingdom». As it should be clear from the preceding pages, Clagett's own approach is wholly different: he does not deny the existence of that continuity which gives sense to the whole project of describing three millennia of «ancient Egyptian science»; but as a true historian he tries to *characterize it* in its relation to, and interplay with the actual intellectual products which grew out of this soil, neither postulating continuity to be self-evident nor identifying the quasi-perennial soil with the changing crop.

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³⁰ S. COUCHOUD, *Mathématiques Égyptiennes. Recherches sur les connaissances mathématiques de l'Égypte pharaonique*, Paris, Le Léopard d'Or, 1993, 11. This formulation is extreme, it is true, since the Papyrus Akhmim does bear witness to considerable change though within a rather stable framework, and because the modest published material indicates that the unit fraction *system* with its strict canon was *not* developed in the late Old Kingdom (according to a personal communication from Jim Ritter, unpublished material proves this definitely). But similar ideas are expressed by scholars of high standing – thus W.F. REINEKE, *Gedanken zum vermutlichen Alter der mathematischen Kenntnisse im alten Ägypten*, «Zeitschrift für ägyptische Sprache und Altertumskunde», CV, 1978, pp. 67-76.