Journal of Ancient Egyptian Interconnections

Egypt's Role in the Origins of Science: An Essay in Aligning Conditions, Evidence, and Interpretations

David A. Warburton
Topoi, Berlin

Abstract

The author argues that the evidence of observation in Egyptian third millennium BCE medicine and astronomy should allow ancient Egypt an important place in the history of science. The argument is primarily based on the absence of evidence of scientific observation in Mesopotamia preceding the Egyptian material, which renders the Egyptian observations of the movements of celestial bodies and trauma the earliest signs of science. While assigning "predictions" and "mathematical astronomy" a more important place, Assyriologists also date what they can document to long after the Egyptian observations and predictions, highlighting the chronological precedence of Egypt. Furthermore, the author stresses a complicated discourse involving the exchange of ideas that was ultimately stymied by the growing importance of religion and magic. Yet the development was not as linear as the usual versions suggest.

Introduction

This paper aims to put two very important themes on the table and link them. Firstly, if Assyriologists, following, e.g., Steele, contend that "it seems very unlikely that [the earliest, mid-second millennium BCE, Mesopotamian] eclipse omens refer to specific events in the past,"[1] then it follows that any evidence of Egyptian astronomical observations in the third and early second millennia would be of great importance to the history of science. And secondly, this very possibility opens up the question of the nature and origins of science itself, where attitudes diverge on the matter of whether the practice of observation, interpretation, or prediction constitutes the appearance of "real" science—or indeed whether one can legitimately demand mathematical precision and exclude religious contexts when proposing conditions for evidence of "scientific practice" in the earliest texts.

This latter problem emerges from the fact that Mesopotamian astronomy appears in the eyes of some observers to be born with observations and predictions being registered simultaneously and thus to have no real prehistory. Peculiarly, they assume that somehow science and religion were originally intertwined and remained that way, while paradoxically contending that the earliest science somehow emerged out of the religious practice. Although this may satisfy some observers, the current writer finds that this is merely the result of applying strict criteria to the definition of "science" which merely leads to circular logic while leaving the entire concept of the developments both obscure and incomprehensible. This methodology—of selecting the criteria—allows science to be "born" at any given specified date (whether in the first millennium BCE or in the European Renaissance or Enlightenment), effectively blocking the way to understanding the origins of science, with the "discoverers" then affecting surprise at this immaculate conception. In fact, however, there is a long history of observation that is documented in Egypt long before the earliest Mesopotamian evidence that the Assyriologists recognize, and thus the current writer suggests that one examine the evidence more carefully.

Ultimately, it may transpire that the understanding of the historians of science is strongly influenced by developments in the West where science and religion were largely conceived as having been and being antagonistic. The Western situation may have been exceptional and misled observers about the relations between science and religion in general and thereby the nature of the origins of science as a whole. And here Egypt is singularly important in understanding developments.

"Science"

Yet, before delving into what I consider to be the relevant elements in the historical sequence, we probably have to agree to disagree about what "science" is and what constitutes evidence of "scientific practice." In my naïve view, science is certainly concerned with recognized universal truths that in some fashion can be used to devise methods of reliably predicting or reproducing results.

In our own age, science is closely linked to medicine and technology with (a) the former being important because it is based upon observation and analysis of biological phenomena allowing (seemingly) incredible processes of healing to become routine and (b) the latter being important because understanding the physics of materials and energy enables mankind to overcome (seemingly) insurmountable obstacles.

Both depend upon an understanding of phenomena that allows some degree of certainty about outcomes. Both also depend upon observation and analysis. Without systematic observations, analysis and prediction would be impossible. One preliminary stage of processing the understanding of observations is a form of analysis without clearly stated premises allowing for alternative outcomes of the analysis. Explanations in "mythical" form represent such a category, where the explanation does not appear to be convincing to us. Thus without the capacity to reproduce laboratory results, or confidently predict or understand astronomical events, mere "observation" and "descriptive analysis" does not appear to be scientific. Yet, if we apply these criteria in a narrow fashion, even today science would still appear to be far from perfected, since physicians are still struggling with cancer and physicists still debate the origins of the universe (which was one of the first problems faced by ancient cosmologists). In many areas, scientists are merely closely observing and recording phenomena without understanding them, at least in the sense of reaching a consensus about the correct interpretation. This means that the observations are being improved or refined, but that debates about the interpretation continue: "the" explanation is missing.

Nevertheless, few would dare to claim that science does not (yet) exist today. On the other hand, however, anyone who denies that science exists today would still have to concede that there is a history of science, since we have a relatively clear idea of what science aims at and what the criteria for scientific success are. And this necessarily leads to the question of when science "started." I claim that without systematic observation and attempts to analyze or explain the phenomena observed, modern science—however perfect or imperfect one contends that it is—would not exist. Others will claim that observations and interpretations alone do not count and that we need more. They presumably expect some "scientific" basis and methodology for the observational procedures and the interpretations, presumably excluding unjustifiable assumptions. Obviously, historians of science can set their criteria, but I argue that historically we should try to go back to the beginnings if we really want to understand the story.

An Anecdotal Beginning

Virtually everyone interested in the history of medicine is aware that, centuries before Hippocrates and Galen, the Egyptians were celebrated as physicians by Homer.[2] Some acquainted with the ancient world will be aware that a half millennium before Homer, Egyptian medics were appreciated in the royal courts of the Bronze Age Near East.[3] Despite these attestations, in recent times Egypt seems to have fallen out of the early history of science, with most of the pre-classical acclaim going to the Pre-Socratics or the Babylonians.

Yet in this contribution I will contend that on several levels, the Egyptians may have provided a few stable building blocks in the history of science, and I will try to reinforce the familiar general remarks with more precise arguments. Of particular importance here are the dates proposed by the Assyriologists in pushing their case, as their tendency to choose progressively later and later dates for the scientific accomplishments of the Mesopotamians reduces the time span of the history of Mesopotamian astronomy, bringing it closer and closer to Hellenistic Greece. This opens up a cavernous lacuna in the preceding millennia of the potential history of science, one that Egypt may perforce be able fill (if the Assyriologists continue to yield on the antiquity of Mesopotamian science).

Beyond that, there is also the question of attitudes toward "science" and "religion," which are themselves also worth examining. It is generally assumed that science and magic were indistinguishable in the ancient Near East. Yet, even quite late in the Bronze Age, we can call on the testimony of Ramesses II for a different appraisal. In the mid-thirteenth century BCE, a Hittite king suggested that Ramesses dispatch an Egyptian physician to the Hittite court to aid his sister in having children. In the response to the request, Ramesses writes:

> Speak thus to my brother [= the Hittite king], concerning what he wrote about Matanazi, his sister, saying "May my brother send me a man to prepare a medication so that she can bear" – So did my brother [= Hittite King] say to me [= Ramesses II]. But I [=Ramessses II] say to my brother: "Look! Matanazi, my brother's sister—your brother [= Ramesses II] knows her! She is a woman of 50 or 60 years of age! A woman of 50 or 60—there is no way that one can prepare a medication for her so that she can have children!
>
> The [Egyptian] sun-god or the [Hittite] weather god can give the command, because it is a magical action that is required and has worked. I, the king, your brother, will send you an incantation priest and a physician who will prepare what is required.[4]

Ramesses is conscious of the limitations of medicine and the possibilities offered by magic, but in this case, he was evidently skeptical about the efficiency of divine intervention. Ramesses understands that medical science is a domain where no magic or religion can help and that magic belongs on the other side, with religion where things are uncertain. This letter should suffice to put an end to the discussion about magic preventing the development of scientific medicine in Egypt, and allow Egypt to be recognized as having had a specific role in the evolution of scientific thought, not only in developing systems of observation but also in grasping the contrast between "religion" and "science."

And this particular situation can be usefully illuminated by drawing on the far more complicated matter of infections. The Egyptians could recognize trauma (such as broken bones) and understood how to deal with such. While infections and contagious diseases could be recognized, the phenomena were effectively incomprehensible when working with the parameters of that distant age. Thus treatment of any kind of disease was a matter of experience and guesswork until the twentieth century CE. Yet, in Egypt, all the problems—broken bones and infections—were all alike viewed as those relating to the human body and thus assigned to the physicians. This seems perfectly normal. It follows that some rather peculiar procedures could be expected in a field where little was understood. And that there will have been some kind of division of responsibilities, but a core of the tradition may have been based on observation and analysis.

Significantly, at the very beginning one encounters a rather bizarre anomaly in the history of medicine. The Egyptian Edwin Smith Papyrus has abundant examples of setting bones.[5] By contrast, Geller remarks of the Mesopotamian tradition, "there is not a single surviving treatise on how to set broken bones."[6] We will soon come to the matter of the Egyptian text, but it is essential to note at the outset that from the beginning Mesopotamian medicine was concerned with phenomena that could not be understood until the modern age, whereas Egyptian medicine began with injuries to bones, and only later began to include other types of illnesses. That the incomprehensible problems of infections led to what we would call "magic" being integrated into medicine is relatively clear. However, there remained the Egyptian tradition of healing trauma, which comes closer to our understanding of "science" (at least as I understand and present my argument here).

The situation in Mesopotamia was, however, quite different, as Geller notes that distinguishing "magic" and "medicine" in ancient Mesopotamia is futile, concluding that "The overlap between these two complementary methods of healing—recipes and incantations—are different means of achieving similar ends."[7] Yet, evidently the tradition of treating broken bones was missing and thus that one part of medicine which could be studied scientifically was excluded. Under the circumstances, it is perfectly logical that Babylonian physicians could be accompanied by incantation priests, as is expressly mentioned in the Hittite correspondence.[8]

I suggest, in contrast to this, that the Egyptians were thinking completely differently. What Ramesses contended was that magic and the support of the gods might accomplish what science could not: magic and science are mutually incompatible alternatives. The goal might be the same, but the intellectual framework is quite different in Egypt. Rather than complementary, magic was a last resort. Unfortunately—but potentially accurately—Assyriologists also extend the contrasting Mesopotamian approach to astronomy, denying a difference between "astrology" and "astronomy," suggesting that "no professional distinction existed between the realm of divination and the practice of scientific activities."[9]

One of the results of this confusion over the issue of "divination" and "observation" is that the Assyriologists are hesitant about accepting that certain records might reflect observations of astronomical events in the late third and early second millennium BCE. Denying this not only increases the confusion about the "scientific" nature of the Mesopotamian records but also places the beginnings of whatever passes for "science" in Mesopotamia much later than would otherwise be possible, which likewise has implications for the thereby heightened potential importance of Egyptian astronomical observations in the third millennium BCE.

Interconnections in the Bronze Age

Yet the situation is far more complicated, for I would not argue that there is a linear sequence leading to modern science, but rather a moving track with false starts, breakdowns, and giant leaps. I assume that there were links between the different parts of the ancient world. Yet there are many (such as Renn in *Globalization of Knowledge*) who suggest that there was little significant communication of knowledge before the European Middle Ages. Thus one must produce some uncontroversial evidence. Some will suggest that there is no written record of the links.[10] In fact, Quack has shown that parallels between an early second millennium BCE Egyptian text called the "Admonitions" and the late third millennium BCE Mesopotamian "City Lamentations" suggest that some scholar had a firm grasp of Egyptian and Sumerian, as well as a mastery of poetry.[11] This can be viewed as written evidence of links as firm as the actual fragments of cuneiform tablets found in Egypt, dating to only a few centuries later.

More important however, was the rapid diffusion of the concept of weighing and the use of uniform weights indicating that there was far more exchange than is indicated when simply looking for written proof—and this before writing was well developed. By the middle of the third millennium BCE, the manufacture and use of the balance and uniform weights was known in the Indus Valley,[12] Mesopotamia,[13] and Egypt. Most significant is that there is no certain evidence of weighing systems in the earliest Mesopotamian texts, whereas the system is definitely documented by the Fara period,[14] at the same time that we have a balance beam in the Indus. The weight system of the Indus Valley, based on a basic unit of around 13 grams, was known in Mesopotamia by the name of the Dilmun *sheqel* and was used in Egypt as the "gold *deben*" of the Old and Middle Kingdoms.[15] The earliest known datable weight in world history—which presupposes a balance—is that of Narmer, probably ca. 3000 BCE.[16] There is no reason to doubt this artifact; yet even if this is disregarded as suspect, there are the depictions of balance beams with weights in the tomb of Hesy-Re,[17] dating to well before 2500 BCE.

This spread of the balance is related to the emergence of equivalency systems. It is widely assumed that equivalencies and exchange systems dependent upon concepts of value are inherently human, but there is little evidence to support this. It is more probable that the concept of equivalencies was developed during the third millennium BCE.[18] There does not appear to be any evidence of equivalencies in the earliest archaic documents from Mesopotamia,[19] whereas the administrative documents from the Ur III period are teeming with what appear to be commercial equivalencies based on weights in silver.[20] From the Old Babylonian period onwards, the bureaucratic administrative texts of the states use the same type of price systems as the commercial systems. Aside from being an Egyptian hieroglyph, the balance appears as a symbol in both Minoan Linear A and Mycenaean Greek Linear B. The systems of estimating value and performing exchange are so uniform around the world that one could argue the diffusion of ideas and methods rather than accidental convergence—and one should hesitate to project the concept back in time if the earliest administrative texts do not appear to rely on it whereas all the later administrative systems do. Thus one can argue that the system of equivalencies based on weights in silver was born in Egypt or Mesopotamia and spread from there to the rest of the world.

Beyond that, the mere spread of the balance and weights should dispel any doubts about the geographical space in which techniques and knowledge were being exchanged. From before the mid-second millennium BCE, the balance was known in the Aegean.[21] It is highly probable that the balance was known in China by the end of the second millennium BCE, but is only demonstrated in the first millennium BCE.[22] Egypt might not have been the first, but the knowledge seems to have spread so quickly that we cannot locate the origin and the knowledge spread to the Aegean and China with the appearance of those civilizations.

In contrast to this reality, Renn states matter-of-factly that "'weight'" technology "is a second-order concept that emerges from reflecting on the knowledge gained by the operation of weighing objects with a balance, a technology developed toward the end of the second millennium in Babylonia and Egypt."[23] The very late date places the alleged invention of the balance close enough to the Greeks that the "second-order knowledge" can be ascribed to them.

Yet the Egyptians and Mesopotamians rapidly developed the concept of "justice," present in both cultures by the end of the third millennium BCE and linked to the sun gods.[24] In both, "justice" was based on "equilibrium" and the balance was used to illustrate this in the fashion they bequeathed to us (and the balance is to this day a symbol of justice in West and East). The Egyptians did not develop a philosophical understanding of levers; this was left to the Greeks and Chinese to explore. Yet the Bronze Age Egyptians were far beyond having a mere concept of weight, having used the balance to advance into philosophy, and the classical world continued with the pursuit—allowing Galileo to begin his work on a completely different level than that which existed before the balances of the third millennium BCE.

In this case, the developments and rapid exchange of knowledge are relevant to understand how science began, developed, and spread. In this case, the actual instruments (which should be unequivocal proof of the diffusion of ideas and technology, for the technology alone would be incomprehensible) play the role of demonstrating conceptual development and exchange between civilizations.

Medicine

Before turning to astronomy, we will briefly look at medicine, since the matter is familiar but neglected, although the significance of the Egyptian contribution probably indisputable. The Assyriologist Geller suggests that the formative period of Babylonian medicine will have begun in the Old Babylonian period (i.e., the first half of the second millennium BCE), with most of the surviving material dating to the first millennium BCE.[25] The Egyptian material is far older: preserved copies of ancient texts are roughly parallel with the earliest known Babylonian medical texts. The formative period of Egyptian medicine can probably be traced back to the beginning of the third millennium BCE, with texts existing by the middle of that millennium.

With the balance, the procedure involved the development of the concept of weight and equilibrium whereby the invention of the actual balance must have played a crucial role. Recording the results could be done in a notation similar to that employed in other systems of measurement. Once the balance was in equilibrium and the result noted down, the operation was complete. In medicine, the initial procedure is identical to weighing, as the basic operation is a matter of observing and analyzing; the second procedure is, however, quite different, as it involves making a judgment about the capacity of the physician to deal with the diagnosis, and then determining the appropriate remedy.

Breasted remarks of the Edwin Smith Surgical Papyrus:

> The facts of each given case of injury are observed, listed and marshalled before the mind of the observer, who then makes rational conclusions based on the observed facts. Here then we find the first scientific observer known to us, and in this papyrus we have the earliest known scientific document.[26]

For Breasted, the text reveals that the Egyptians had a relatively objective view of medicine in the third millennium BCE. The system was based upon examining the injuries, diagnosing them, deciding whether one could treat them, and then either abandoning the sufferers to their fate or treating them. Breasted remarks that the specific titles of a court physician of the mid-third millennium reveal that the specialist "was particularly well versed in internal medicine."[27] Thus, we have not only the surviving copies of the copied texts but also the original tombs of some of the world's earliest physicians.

Breasted elaborated on the systematic methodology of the physician who wrote the oldest medical papyrus. He stressed that he proceeds downward from wounds to the head to injuries of the legs (the first and final parts of the papyrus having been lost, we do not have either the introduction or the section on the feet). For the individual cases, Breasted summarizes the approach:

> The discussion of each case in itself likewise discloses a systematic order of materials and topics—an arrangement which, with the exception of some elaboration in six cases, is always strictly followed. It is as follows:
>
> 1. Title
> 2. Examination
> 3. Diagnosis
> 4. Treatment (unless a fatal case, considered untreatable)
> 5. Glosses (a little dictionary of obscure terms, if any, included in the discussion of the case).[28]

The system is nothing if not rigorously methodological, and based exclusively on observation and analysis. I make several points.

Firstly, (1) it is clear that virtually all of the cases in the oldest version of this oldest text are probably injuries resulting from military activity (ranging from the fatal blows of weapons to sprains probably originating when fleeing the battlefield or pursuing fleeing enemies). This can be directly related to the motivation of the state in pursuing its interests through military activity and attending to the needs of dying and injured soldiers. These blows may well have been produced by the maces for which the Egyptians are celebrated, the use of which declined shortly after the formation of the state. Thus, one could imagine that parts of the text take us back to the beginning of the third millennium

BCE.

Secondly, (2) the injuries are easily recognizable and diagnosed. This is a matter of observation and analysis.

It could be suggested that Breasted's optimism was that of an enthusiastic admirer of ancient Egypt in the early days and that his analysis was not quite what one would actually find in the texts. By contrast, Green's approach is hardly less admiring:

> Palaeopathological studies in Egypt have provided a great deal of information to the bioarchaeologist over the years, revealing epidemiological trends, subsistence practices related to health, and especially the capabilities of the medical practitioners and their vast knowledge of the human body and its ailments. Thanks to the excellent preservation of the remains, osteologists and palaeopathologists have also been able to shed light on their limits. Dental diseases were clearly the most prevalent disorder, followed by general pains from osteoarthritis, trauma from every day life or perhaps war, and disorders related to a poor diet such as cribra orbitalia and the manifestation of Harris lines. […] Parasitic worms also flourished in the bodies of the Egyptians, no doubt a result of poor sanitation procedures at the time. Not surprisingly, the medical papyri shed light on the majority of these ailments, with particular detail given to traumatic injuries, parasites, and joint stiffness or aches. Evidently, despite having a systematic process of examination with diagnostic principles and a series of prescriptions for each affliction, the treatment methods employed by the ancient Egyptian physicians were not always effective.
>
> However, remedies that proved to be successful extended across Egypt's borders. In fact, a number of the remedies presented in the papyri are similar to modern methods of healing, namely the methods of fixing a dislocated jaw, removing external swellings by discharging pus, and splinting broken bones. Dawson […] states, "The popular medicine of almost every country of Europe and the Near East largely owes its origin to Egypt, and in its various migrations it has preserved its ancestral form and its very words and phrases almost intact throughout the ages." This unsurpassed knowledge of human diseases and ailments was clearly recognized, leading to the reproduction and perpetuation of these papyri throughout Egypt's civilization.[29]

Thus, in light of this, one must admit that Egyptian medicine was probably deservedly admired in antiquity. One question that deserves to be posed is just why this advanced research is not more widely recognized.

Geller correctly remarks that, "[j]udging from the extant Egyptian medical corpus, it is far from clear whether funerary experts mummifying bodies transmitted the fruits of their anatomical experience to Egyptian doctors" and concludes authoritatively, "[i]n general, prior to the third century BC no scholars in antiquity had any real understanding of internal human anatomy."[30] It is possible that the Egyptians had some knowledge of the internal organs, but it certainly cannot be viewed as impressive. Yet, the important element is that the earliest Egyptian texts were based on observation and analysis. And—of course—that the Mesopotamian sources offer nothing about fixing broken bones, as Geller concedes, thereby opens up a domain where Egyptian science was well ahead of the Mesopotamians.

Only later did the complications of diseases become a concern of medicine. Thus, there is a history that is dismissed, despite the fact that Egyptian physicians were celebrated even in the classical world; Egyptian medical experience was already ancient by the time of the classical Greeks—and it was scientifically based, at least to the degree that observation and analysis were intimately intertwined. Yet these details are neglected, suffering from a direct comparison.

And thus my third point: (3) like the Mesopotamian medical texts, the later Egyptian "medical" texts include a great deal of what we would call magic. However, this concerns completely different types of illnesses and injuries, illnesses that were not understood until the nineteenth century CE (and later), when modern scientific medicine began to grasp the importance of issues such as hygiene due to the mastery of germs. For the Egyptians, many illnesses will have remained mysterious, as will have been the (positive and negative) effects of certain herbs and other materials ingested or touched by humans. Such phenomena will have appeared to be incomprehensible in comparison to the ordinary trauma of warfare. Yet the Egyptians (like the Chinese and the Mesopotamians) obviously understood medicine globally—as care for the body—and did not distinguish between "injuries" and "diseases." Obviously, one can hardly criticize the Egyptians for having failed to tackle such problems, and thus they did include what we call magic in their explanations and prescriptions for some ailments. As a result of this latter mixture, it is frequently assumed that the ancients did not understand the difference between science and magic.

However, in Egypt, this magical content is not that prominent in the third millennium. It appears from the second millennium onward (which is the time when Babylonian medicine arises). This means that there is actually a transformation in thought. Confronted with incomprehensible phenomena—which were recognized—physicians may have been tempted to turn to magic. However, above we noted that Ramesses II had a very clear impression of the situation that magic differed from science. We should abandon our illusions about the naivety of the ancients about the difference between religion, magic, and science in medicine. It can hardly be claimed that the Egyptians were unaware of the differences. However, when confronted with the insoluble, they sought magic.

Under ordinary circumstances, Ramesses's letter—in conjunction with Breasted's discussion of the Edwin Smith Surgical Papyrus—should suffice to see that observation preceded magic and superstition. The fact that the major deities of the relevant states are responsible for magical practices should also be noted, as these deities are not prehistoric, but rather emerged with the states.

Fourthly, (4) there is one philological remark to be made about the nature of these "magical" or "religious" elements in Egyptian medical texts. An example of such are the *wḫd.w*, a term occasionally translated as "demon" or more objectively as "*Schmerzstoffe* (*auch Krankheitsdämon*)."[31] Translating this as "germ" (*Keim*) would give the texts a completely different flavor. Thus the translations contribute to the aura of magic, perhaps enhancing aspects of the texts that were never present.[32]

If the Mesopotamian texts reveal a different pattern of historical development, it is possible that the Mesopotamian scribes began their medical system after the Egyptians and thus began with the assumptions of the Egyptians. Were this the case, it would imply that the Mesopotamian system followed long after the Egyptian breakthroughs of the third millennium and began to develop when Egyptian physicians were wrestling with intractable problems; the gradual incorporation of "magic" into "medical science" in Egypt may have reflected the discovery of diseases which could not be explained and remained inexplicable until recent times. In this sense, modern medical science is the continuation of what the Egyptians started in the third millennium BCE and did not follow the false track of the Babylonian discipline. The introduction of "magic" may have been a secondary development in Egypt, and this secondary development was a primary feature in Babylonian medicine, suggesting not only exchange, but also an evolution in thought.

This is extremely important for the discussion of the antiquity of Mesopotamian astronomy, as the evidence may imply a far more complicated process of both the history of observation and the mixing of religion and science—and the exchange of ideas at different levels of development.

Astronomy

The Ideological Context

Swerdlow represents a modern attitude toward Babylonian accomplishments:

> […] as Neugebauer pointed out again and again [… the Babylonian scribes] developed a mathematical and scientific interest in the intricacies of lunar and planetary phenomena […] Revolutionary it was, the origin, I believe of science as we still understand it.[33]

Viewed in a different fashion, this could be interpreted as meaning that the Mesopotamians applied mathematics to the movements of the heavenly bodies but were unwilling to adjust their philosophical visions, so that inquisitive science did not really separate out of their mindset to create a new view of the world. Ordinarily, the difficulties are ascribed to Mesopotamian science being embedded in religion: whereas in 2010 Rochberg simply observes that the astronomers and astrologers were the same, in 2012 Graßhoff transforms the banal reality into a "thesis."[34] If the mixture of "divination" and "science" was so deep rooted, one could contend that the claims for the scientific parts of Babylonian astronomy may be exaggerated—or one could accommodate the Egyptians. Yet this is apparently unacceptable.

The example of Babylonian medicine has just been covered. Egyptian medicine can be traced back to the third millennium BCE whereas Babylonian cannot. Babylonian medicine began in the second millennium, working with the assumption that magic and medicine were one, being far more heavily influenced by religion and magic than was Egyptian medicine. Yet, in following this route, they were adopting an impression that was gradually appearing in Egypt, where physicians sought more understanding of diseases and cures and found themselves at a loss to understand, explain, and heal. Yet, even at the end of the second millennium BCE, Ramesses knew the difference. Thus, the earliest medicine in Egypt was based on relatively objective observation and analysis and only later came to include elements that we must view as being irrational. If we accept the testimony of the Assyriologists Rochberg and Geller, we must assume that in Mesopotamia this distinction was not clearly expressed in the heads of the scholars involved—and that, in both astronomy and medicine, magic and religion were involved from the outset. This would imply that they were adopting ideas from the Egyptians, and this takes us to the core of the present discussion.

While Mesopotamian science is gradually being increasingly accepted as the predecessor of Greek science, Egypt is edged out of any possible role in the history of science as practiced by mainstream authorities. Yet there are grave difficulties facing the attitude that the Babylonians invented science unaided. Among these is the patently absurd statement by another Neugebauer *Schüler* to the effect that "the foundation of Babylonian astronomy" lies in texts of Achaemenid/Hellenistic date.[35] Graßhoff not only confuses "zenith" with "foundation" but also fails to recognize that the era is post-Babylonian and thus open to Greek influence. This peculiar conclusion is then followed by the suggestion that we lack an idea "of the genesis of later Babylonian astronomy."[36] This is evidently the most that contemporary scholarship can do to conceal the inadequacy of their progress with Neugebauer's (1954) challenge that "Whatever prehistory [of Babylonian astronomy] we reconstruct is […] of a very conjectural character."[37]

Babylonian & Greek Astronomy

Thus, in effect, modern scholars assume (a) that Mesopotamian science was always mixed with magic and religion and (b) that the origins of Babylonian astronomy lie in some period that they cannot locate, while (c) frequently concluding that Babylonian discoveries only slightly antedated those of the Greeks.

Based on Herodotus, Thales is reputed to have predicted the general temporal limits of a solar eclipse that modern science assumed took place on 28 May 585 BCE (συνεστεώσης τὴν ἡμέρην ἐξαπίνης νύκτα γενέσθαι. τὴν δὲ μεταλλαγὴν ταύτην τῆ ἡμέρης Θαλῆς ὁ Μιλήσιος τοῖσι Ἴωσι προηγόρευσε ἔσεσθαι, οὖρον προθέμενος ἐνιαυτὸν τοῦτον ἐν τῷ δὴ καὶ ἐγένετο ἡ μεταβολή; Herodotus I: 74). Although one can dispute that Thales did anything of the kind, it should be evident that, less than two centuries later (in the fifth century BCE), the credulous Herodotus repeats something that he had heard and that it concerned the prediction of an eclipse. Couprie argues that, based on personal observations and analysis, predicting this particular eclipse was (exceptionally) possible without Mesopotamian aid.[38] According to this hypothetical idea—assuming that the tale is correct and that he did predict an eclipse—Thales was wildly lucky.

However, this draws attention away from the question of whether the Mesopotamians had accumulated enough material by this time to accurately predict eclipses on their own. There does not seem to be a consensus about either the earliest successful Mesopotamian (a) eclipse observations or (b) eclipse predictions. For rather doubtful reasons, as Goldstein notes, scholars argue "that the Babylonians began systematically to record astronomical observations in 747 B.C."[39] And in any case, they never understood how they functioned.

By contrast, Arrian's remarks on Alexander's sacrifices to moon, sun, and earth (ἔθυε τῇ τε σελήνῃ καὶ ἡλίῳ καὶ τῇ γῇ; Arrian III: 7, 6) demonstrate that Arrian knew the causes of a lunar eclipse. Yet this does not demonstrate that Alexander did on 20 September 331 BCE. On the other hand, however, Rochberg remarks that, for the Greeks, "the mechanism of causation can be explained in terms of Aristotelian Physics" and stresses that this is Greek rather than Babylonian.[40] Whether Aristotle's influence explains Alexander's alleged action is unclear, but the understanding of astronomy was growing, and Greek science followed immediately on whatever they could have acquired from the Babylonians.

Thus, the Greeks evidently had an independent tradition of reflecting on celestial phenomena—and curiously, the Babylonian documentation explodes after Alexander's conquest as the greatest part of the Mesopotamian *Astronomical Diaries* postdates Alexander's action and virtually none of it antedates Thales. In this context, one recalls a strikingly interesting sentence of Neugebauer's:

> […] I think that one has to concede to early Greek astronomy a good measure of independence, in particular so far as geometrical considerations are concerned and also with respect to the trend to numerological speculation.[41]

Obviously, the idea of mutual interaction and parallel development could explain a good deal.

The striking contrast of the quantity of Babylonian material dating to the Hellenistic era—as opposed to the paucity of Assyrian and Babylonian material—could be explained in terms of a changing economic climate. And this economic climate may perhaps be related to a change in the understanding of science. One of the most radical changes was that at Uruk, where the worship of Anu overtook that of Inanna with the onset of the Achaemenid period, as implied by dated documents that can be related both to the respective temples and personal names; aside from disturbing things, one sees little imperial interest.[42] Seemingly, Xerxes and the other Achaemenid rulers had little time for Babylonian astronomy. During the Achaemenid and Seleucid eras, the temples were largely freed from state support and the priests left free to pursue their own economic interests while being paid quite well by the temples,[43] which had largely become the domain of the priests, who themselves defined the capable astronomers and priests.

It is logical that this royal "deliberate neglect" of the traditional cult to the advantage of the Lord of the Heavens could possibly be related to the abundance of Mesopotamian astronomical observations suddenly appearing during this era.[44] The Assyrian and Babylonian kings were quite concerned about astronomical events and received direct support from court-paid experts. Such professions were no longer required in the later era when the Persian and Hellenistic rulers adopted a secular approach to science and privatized the temples. Thus what had hitherto been a royal pastime (for most celestial events were related to states and kings) was also privatized, opening up astrology to the masses and offering a lucrative source of income for the priesthood.

Thus, one can see an economic explanation for the change in the proportions of the material. And one can relate this to hard-headed science. In the Mesopotamian tradition, the experts could consult the sources and "explain" the meaning of an eclipse after the fact (based on records potentially taking us back centuries) and offer advice about royal conduct. Astronomical events were observed because they were understood as divine in the Mesopotamian tradition, and the experts were required at court because celestial actions concerned royalty and the state.

Rochberg observes that the Greeks were philosophical: eclipses could be explained and predicted. As eclipses were related to celestial movements rather than divine intentions, eclipses were of marginal interest to the state and royalty. The implication of the abundance of the Mesopotamian documentation and the withdrawal of royal attention to the gods is that this understanding emerged during the Achaemenid period, since the respect for the local gods of the heavens ceased relatively soon after the Persian conquest of Babylon. However, the priests and astronomers may well have appreciated that they could (a) exploit the superstitious masses while (b) using Greek methods to predict events. This would invert our understanding of the importance of the *Astronomical Diaries* for Mesopotamian science.

And this in turn could also be set in line with a changing attitude toward Babylonian astrology after the emergence of the Hellenistic kingdoms eclipsed Greek experiments with "democracy" and science. The production of such material might well have increased in a world where self-expression was (a) extended to appropriating the royal prerogative of astrology while (b) being strictly reduced in terms of political options. It was at precisely this era that Aristotelian science became fossilized and Greek thought followed different avenues in which curiosity failed to play a role. One can trace Babylonian impact on Egypt and Greece in the form of the zodiac that spreads at this time. Significantly, von Lieven notes that by the Roman era, the astronomical bits of the ancient Egyptian *Book of Nut* had been discarded so that only the "religious astronomy" is preserved.[45] One can easily imagine that the exotic character of the Babylonian astronomers and their complicated thoughts actually increased their market value in such an environment. Thus the Hellenistic material from Babylonia might well reflect the simultaneous demise of Greek and ancient Near Eastern science and the rise of the specifically individual religious thought (at least partially spurred by private greed).

Regardless, the evidence confirms a good deal of exchange in the Greco-Roman era. Nevertheless the key points of the observations of Arrian and Herodotus and the earlier Babylonian tradition is that either (a) the Greeks were developing astronomy in parallel with Babylonian astronomy, or (b) the foundations of Babylonian astronomy lie much further back and remain to be discovered rather than left in the obscurity Neugebauer highlighted.

In reality, however, it seems rather odd that the numerous cuneiform sources for astronomical observations before the first millennium BCE are neglected: the Assyriologists seem loath to take up the torch. For those outside of Assyriology, it is clear that Mesopotamian observation of the heavens can be traced back to the Uruk period (when months and years are mentioned in the texts) and highly probable that the systematic recording of astronomical observations was already practiced before the Old Babylonian era. Gasche et al.[46] argue that some of the omens of the *Enūma Anu Enlil* series reflect astronomical observations that go back to the beginning of the second millennium BCE. The central claim here is that omina in the *EAE* collection represent records of Ur III observations of two lunar eclipses. In this case, Koch has confirmed that the textual records of the omina more or less match the astronomically reconstructed lunar eclipses (of 1954 and 1912 BCE) proposed by Gasche et al., with the exception that one of the two eclipses is described as having lasted longer than it actually did (and could have).[47] Steele et al. note similar cases of observed first millennium BCE eclipses with similarly impossible durations and ascribe the discrepancy to a "scribal error," which is logical enough.[48] Thus, one could have an argument for maintaining that the history of Mesopotamian astronomy could be projected back to the beginning of the second millennium.

Yet, concerning the second or third millennium Mesopotamian data, the Assyriologist Steele concurs with the Assyriologist Hunger that "there is considerable doubt both about whether these [early] omens have any basis in observation and their association with particular historical events."[49] Like others, Steele would allow celestial observations in the second millennium BCE but still stresses that Mesopotamian "material is very scarce until the Late Babylonian period (ca. 750 BC to AD 100), with the vast majority of texts coming from the last four centuries BC."[50] This places us in a very difficult position if this material is to be interpreted as Mesopotamian, and it means that the Mesopotamian material is Hellenistic.

Nevertheless, Brack-Bernsen and Steele allow that the Babylonians had sufficient data "to calculate the times of predicted eclipses […] by at latest the mid-sixth-century BC."[51] They assume that the method

> almost certainly originated with lunar eclipses and was then applied to solar eclipses. Indeed, it is most likely that all Babylonian eclipse theories—for want of a better term—were developed from lunar eclipse observations and used for predicting lunar eclipses and then applied by analogy to solar eclipses.[52]

They also stress that "the earliest eclipse records we possess apparently begin in 747 BC, and already they include predicted eclipses."[53] In effect, therefore, Brack-Bernsen and Steele allow that the Babylonians were indeed observing and predicting eclipses in the early first millennium BCE, but they assume that the Babylonians had discovered a saros cycle of 223 months and that this was their basis. Such an assumption does not demand understanding (as indicated by Alexander's sacrifices), but it does allow precision (which Thales apparently did not match). The implication might be that the Babylonians were quite late and differed from what the Greeks were doing, which creates something of a paradox when trying to disentangle historical developments.

Another problem is the issue of observation, which is ultimately the basis of theoretical analyses. On inquiry (by the current writer), both Rochberg and Steele have personally confirmed their skepticism about the viability of interpreting the Ur III omens of the *EAE* as being records of observed eclipses. Thus while Steele assumes (a) that the Mesopotamians "were always observing the moon"[54] he denies that the *Enūma Anu Enlil* documents recorded observations of lunar eclipses. Yet eclipses did take place corresponding to the data of the omina (according to Koch and NASA), and thus the Assyriologists deny their own texts and the astronomical events—but only before the second quarter of the second millennium BCE, so that in the first millennium, the data is accepted.

Regardless, *pace* Steele as quoted at the outset of this essay, the Assyriologists deny the only records that could confirm early Mesopotamian observations and stress the abundance of Hellenistic material. Let us take the Assyriologists at face value. Thus, it is assumed that whatever Thales was using as the basis for his calculations (if one accepts the story!) must (a) have been a matter of luck or (b) have been of Babylonian origin, since there is no evidence of the necessary later Greek astronomical observations that could have offered a foundation. Certainly even if the Nebra Disk and Stonehenge could be taken seriously for potentially betraying some knowledge of the heavens, the pre-Mycenaean Greeks were probably not observing the heavens systematically. Thus Thales could not have had his sources locally. Yet the Assyriologists deny the evidence available at an early point in the second millennium. Thus the potential origins of Babylonian science become quite interesting.

Early Egyptian Astronomy

And it is at this point that we come across a very interesting phenomenon, for we know that before the end of the third millennium BCE, the Egyptians were not only familiar with the phases of the moon, but actually tracking stars and planets as well. Parker states matter-of-factly that by 2150 BCE, the "star clocks" confirm that the Egyptians were tracking the stars.[55] Von Lieven agrees with Neugebauer and Parker that the astronomical dates in the *Book of Nut* imply an origin in the Middle Kingdom.[56] Von Lieven is probably correct in suggesting that such "star clocks" were maintained up-to-date until ca. 1850 BCE; certainly, from the eighteenth century BCE onward, they were uncomprehendingly copied for a half millennium and more.

Von Lieven assumes that the "star clocks" were abandoned as observational difficulties arose with precession rendering the comprehension of the earlier observations of specific stars difficult. Yet, somehow, the regular observations of Sothis, which was one of the decans tracked, continued. However, Sothis served a practical role in agricultural life and thus had to be observed, and the difficulty of precession was overcome. I suggest therefore, more mundanely, that with the gradual collapse of the Twelfth Dynasty, beginning in the nineteenth century BCE, the complications of synchronizing civil and solar calendars became insurmountable as methods were forgotten and pressing social problems grew. Regardless of the reason, the link between the stars and the calendars was forgotten. This introduced a break in the path, allowing Egypt to be thrown out of the loop in the history of astronomy long before Hellenistic times.

Regardless of the lapse after 1850 BCE, it would nevertheless mean that we have documented regular, systematic astronomical observations of the stars in Egypt for some three centuries.

Yet, the history can be traced back, further, before the twenty-second century BCE. Following up on discussions that take us back to the beginning of the twentith century CE, Krauss has argued that analysis of the *Pyramid Texts* (first recorded in the tomb of Unas, ca. twenty-fourth or twenty-fifth century BCE) confirms considerable knowledge of the movements of the moon, planets, and stars. Among his points is that "the evidence suffices to identify the celestial *ḫꜣ*-canal [featuring in the *Pyramid Texts*] as the ecliptic."[57] One aspect of the evidence is the shifting nature of the canal. Another is the curving nature of the *ḫꜣ*-canal, which likewise matches the graceful lines of the ecliptic. Another is the clear consciousness that the ecliptic was the path of the sun—which is remarkable considering that the sun was not visible at night. This means very careful observation and analytical thought. One of the most important features of the *ḫꜣ*-canal are the *ḳꜣb* coils,[58] which Krauss is persuaded can be related to the apparently retrograde motions of the planets within the ecliptic.[59] These apparently retrograde planetary movements are the result of viewing the planets from the earth, since at certain moments the earth's orbit around the sun gives the earth-bound observer the impression that the planets briefly go into reverse before resuming their normal path.[60] Thus, Krauss's interpretation of the evidence implies that the Egyptians recognized the ecliptic.

Other observations and conclusions drawn by Krauss are admittedly controversial (in the sense that they are not accepted; although it is entirely possible that one day some of them will be, some are disputed today). However, in this, Krauss has the full support of Allen who, despite some doubts on other issues and detailed philological criticism, observes that Krauss

> is able to show that this [i.e., the *ḫꜣ*-canal] was viewed as a strip […] winding through the sky from east to west and argues convincingly that it reflects the ancient Egyptian observation of the ecliptic, the 12° wide arc that the sun, moon, and visible planets generally follow in their apparent motion across the sky. This is perhaps the single major contribution of Krauss's study […][61]

Thus, the observation of the heavens concerned the Egyptians, and the identification of the ecliptic means the careful observation of the sun and the planets. Yet rather than developing mathematical or theoretical models, their understanding remained descriptive and analytical, based on close observation and recording as well as their social interpretations of celestial phenomena as being related to the king.

Others have followed other leads in Egyptian astronomy, e.g., Belmonte and Shaltout.[62] Spence has argued that the Egyptians may have used astronomical sightings to align the Great Pyramid,[63] meaning that we can extend our claims of Egyptian astronomical observations as far back as the twenty-sixth century BCE.[64]

Neugebauer and the History of Science

Obviously, a good deal of this is still debated, but the star observations of the Middle Kingdom and the ecliptic of the Old Kingdom are not, and thus we have regular systematic observations of astronomical phenomena for more than half a millennium, from ca. 2500—1850 BCE.

In this sense, the current situation differs substantially from a claim by Neugebauer:

> Nothing in the texts of the [Egyptian] Middle and New Kingdom equals in level, general type, or detail the contemporaneous Mesopotamian texts.[65]

In fact, the Assyriologists deny having any materials contemporary with the early second millennium BCE Middle Kingdom—let alone the third millennium Old Kingdom *Pyramid Texts* mentioning the ecliptic.

Whereas Neugebauer was persuaded that the Babylonians and Greeks contributed significantly to science, he expressly assumed that we knew little about the origins of Babylonian astronomy. The current situation is that apparently there is little to be learned before the first millennium BCE, and this absolutely contradicts Neugebauer's statement that the material from second millennium BC Egypt was not equal to "the contemporaneous Mesopotamian texts."

Thus, there is a tendency to assume that the history of science belongs to the Greeks, who took up the torch from the Mesopotamians; yet the Assyriologists steadfastly deny the existence of Mesopotamian materials that could match the now recognized contributions of the Egyptians. The result is that the history of astronomy is compressed into parallel developments in Mesopotamia and Greece during the first millennium BCE, with the Mesopotamians just barely ahead of the Greeks. Any potential Egyptian influence is dismissed for precisely that period during which Neugebauer and Graßhoff vainly assume Mesopotamian contributions.

Significantly, in the course of his discussions Krauss can demonstrate that Neugebauer and Parker followed false leads when studying the Egyptian material, with the result that they did not grasp the content of the texts. This is extremely significant since Neugebauer insisted that the ecliptic was not discovered before ca. 500 BCE[66]—and this remains seemingly largely uncontested today, despite Krauss's work. It is true that Neugebauer's understanding of the ecliptic was probably such that only the Greeks can be recognized as having discovered it.

However, if we are talking about the history of science, we are talking about increasing understanding. The evidence of the Egyptian sources is that, based on observations, the Egyptians reached an understanding of the ecliptic and thus the movements of the sun, moon and planets. They were clearly conscious that the stars moved in a completely different fashion, and they likewise recorded these annual movements. In this sense the Egyptians observed, recognized and understood the movements of the heavenly bodies.

Thus, one is in the position of suggesting that the Egyptians may have discovered the ecliptic around two millennia before Neugebauer thought that anyone had and that the Egyptians maintained a practice of astronomical observation for a bit less than a millennium after their initial discoveries. This then faded away in the era after the Middle Kingdom. In terms of science, the importance of their contribution would lie in their perseverance in observing and recording. In terms of human history, it would appear that the Egyptians will have been the first to identify the celestial phenomena as gods and to relate the activities of these celestial beings to social events here on earth, centering on the king.

Yet at the same time that the Assyriologists deny the early Mesopotamian observations, they claim that the origins of astronomy lie in Babylonia. Yet this means that the Assyriologists propose that a vacuum denies the precedence of the Greeks. Although some Greek practices may parallel the Babylonian, some Babylonian practices antedated the Greeks—but not by much according to the Assyriologists. Of far greater importance is, however, that as a consequence of stressing the Greeks and the Babylonians, the practitioners of the history of science completely neglect the Egyptian materials that definitely antedate the earliest evidence of Mesopotamian astronomy.

Of particular significance is that, having studied Egyptian observations of the moon, using lunar and civil calendar dates, Krauss has suggested that the Egyptians were relatively reliable observers.[67] Yet the response to the claims has been a chorus chanting that the dates "are too good to be true"[68] rather than appreciating that the Egyptians might have been reliable observers.

The second angle is to suggest that the crucial difference is that "science" is based on "mathematical astronomy" as opposed to "observational astronomy." Yet the complete absence of early Mesopotamian observations is complemented by a complete absence of mathematical astronomy. By contrast, the Egyptian observations are not complemented by "mathematical astronomy": one has the impression that we are witnesses to an historical process that confirms that the roles of "observation," "recording," "analysis," "theory building," "prediction," and "understanding" contribute together to the emergence of modern science and that one must follow these leads to their beginning, recognizing each one individually. Some contribute to the framework of science, and some represent real progress up the ladder. But each has a role.

The Beginnings

In fact, it may well be that, contrary to the assertions of the Assyriologists, the Mesopotamian observations (in medicine and astronomy alike) began just before (in the Ur III period) or in the course of the Old Babylonian period, as one can conclude from the admittedly scanty evidence. However, there is no hint of anything earlier in Mesopotamia and—according to Parker & Neugebauer but *contra* Neugebauer!—the Egyptians were making observations of the stars. And according to Allen, following Krauss, the Egyptians also observed the ecliptic. This would imply that the Mesopotamians took the torch from the Egyptians, whose own skills could bring them no further, as is evidenced by the gradual increase of magic in medical texts and the failure to understand how to maintain their star charts.

Yet the story is still more complicated.

It is clear that the earliest (Uruk III, end of the fourth millennium BCE) temporal divisions from Mesopotamia include the concept of a 360-day year,[69] which was clearly dependent upon their complicated version of the sexagesimal system. The same is true of the artificial 30-day month, 12 of which fitted so perfectly into their mathematical system that one might even propose that 12-month year and 360-day year were born together in a single inspired moment of analytical contemplation.

The Egyptians were in a position to observe that the year was neither 360 nor 365 days—and that months were not regularly 30 days, either. However, for calendrical purposes, the Egyptians used the 30-day month and for administrative purposes frequently viewed "the year as of only 360 days."[70] I doubt that this is a coincidence. The only reasonable explanation for the Egyptian use of the 360-day year and 30-day month would be to propose that they adopted these—against their better wisdom and decimal conceptual system—from the Mesopotamians at the dawn of history.

It will be appreciated that this contradicts Parker's claims that the prehistoric Egyptians developed intercalary months etc. and suggests that the Egyptians invented the calendar year.[71] One of the most telling arguments against this interpretation is Spalinger's judgment that Parker's arguments are so complicated that one must read Parker several times in order to really understand the argument.[72] This implies to me that Parker was confronted with the reality of the Egyptian calendar and tried to find a means of accounting for how the Egyptians could, on their own, have created such a simple and yet useful system (which was nevertheless not compatible with reality). It is possible, but hardly necessary. I agree with Neugebauer: the idea is based on "very implausible" assumptions; it is improbable that the Egyptians were carefully observing the heavens in the fourth millennium BCE; "the whole Egyptian calendar does not presuppose any systematic astronomy whatsoever."[73]

It is far easier to assume that the Mesopotamians with their sexagesimal system created a convenient (but oversimplified, erroneous) system and that the Egyptians adopted this around the beginning of the dynastic era (when years were given names as in Mesopotamia, rather than the count and regnal years as later). The Mesopotamians later introduced intercalary months, but the Egyptians did not. There is no proof that the scribes responsible for the earliest archaic texts were working with a calendar year long before Uruk III, yet the Uruk IV scribes had the concepts of years and months. One can postulate that their accounting for time was developed at the same time as their other systems of measures (which still excluded weights at this time), based on the sexagesimal system. I argue that the Egyptians adopted the year from the Mesopotamians after the time of its adaptation in Mesopotamia.[74]

An Excursus on Prehistoric Calendars

I should add that if Parker's claims about alleged Egyptian prehistoric observations are allowed to pass, then it should be impossible to dispute the astronomical calendar (with 56-year eclipse cycles, which might be related to saros cycles) built into Stonehenge, as Hawkins claimed.[75] This Stonehenge calendar would be roughly contemporary with the Egyptian observations of the ecliptic. Although the method of recording is admittedly ponderous and unorthodox, we would have a powerful means of predicting eclipses. Yet the astronomical basis of Stonehenge is routinely rejected. This is hardly surprising, since the authorities cannot accept that "prehistoric peoples" were far ahead of where the Assyriologists would have us believe the Mesopotamians were in the first millennium BCE. Certainly, the Egyptians were not that advanced in the astronomical systems in the fourth millennium BCE. Thus, I would claim that the Egyptians adopted the calendar from the Mesopotamians.

Yet, if one accepts Parker's argument, it means that Stonehenge cannot be denied. And that would mean that the Egyptians and the Mesopotamians were behind the builders of Stonehenge in the third millennium, since neither the Egyptologists nor the Assyriologists contend that anyone in their areas was predicting lunar eclipses at that time—let alone capable of solving the problem of the length of the year.

Thus, although many will doubtless dispute it, my own suspicion is that the Egyptians had originally adopted a 360-day year and 30-day month from the Mesopotamians. Both are artificial and result not from observation or the simplification of observation but rather from mathematics, as 12-month year and 360-day year move hand in hand. The Egyptians excelled at observation but not at theoretical simplification, and thus such a haphazard calendar would hardly have been a typical creation of the early Egyptians. The adoption of the 360-day, 12-month calendar in Egypt can be reasonably assigned to Mesopotamian influence rather than coincidental accident (which is rather improbable since observations could never link the lunar year of 354-odd days to a year of 360-odd days, quite aside from the easily observed irregularity of the length of lunar months).

Yet, it is hardly surprising that the observant Egyptian scholars realized over time that this 360-day year was inadequate, with the initial response being the addition of the epagomenal days. Based on the preserved documentation and the role of the Osiris family tale hinted at in the *Pyramid Texts*, I suggest that the epagomenal days were added around the beginning of the Fifth Dynasty and neither earlier nor later. Henceforth, they used a 365-day year for calendric purposes and a 360-day year for administrative purposes. Based on its appearance in the *Pyramid Texts*, one could argue that already in the course of the Fifth Dynasty the decan Sothis was established as a control mechanism, so that sightings of the heliacal rising of Sothis allowed one to anticipate the inundation and thus to calibrate the calendar. Obviously, this is a matter for debate, but it would be an indication of the pragmatic nature of Egyptian science.[76]

Central is that the Egyptian year separated itself from the Mesopotamian year in the course of the third millennium BCE, based on observations in Egypt and not make-shift, arbitrary, intercalary months as was the solution in Mesopotamia. Once the principle was recognized and applied in Egypt, it was possible to "predict" the movements of the stars, as is documented with the early second millennium Illahun/Kahun Sirius/Sothis date, which is a prediction of the heliacal rising of Sothis: on 7 III *prt* 25, the author of a letter informed the reader of the letter that the heliacal rising of Sothis would take place on IV *prt* 16, i.e., a few weeks later.[77] Although it was a prediction, it may be assumed that the Egyptians were cautious enough to try to verify the sightings year for year. Regardless, once the technique was used and the sighting verified its viability, the Egyptians no longer needed to adjust their calendar years, since they could predict the beginning of the solar year in terms of their calendar.

In this context, it is worth noting that the earliest predictions come much later in Mesopotamia, apparently in the first millennium BCE. Significantly, Neugebauer contended that "astronomy does not originate with the recognition of irregular configurations of stars," but he insisted instead that "[s]cientific astronomy does not begin until an attempt is made to predict, however crudely, astronomical phenomena such as the phases of the moon."[78] Obviously, by this time, in the early second millennium BCE, the Egyptians had more than a crude understanding of the phases of the moon; predicting the reappearance of Sothis was far more of an accomplishment.

Yet, my own claim is that all kinds of prediction are based upon the long-term observations that preceded them and therefore that Neugebauer was denying the origins of science by insisting on prediction. It is absurd to deny the origins and then assert that the late first millennium BCE "scientific" astronomical observations of the Babylonians can only have a prehistory "of a very conjectural character" (as Neugebauer does).[79] It would be easier to recognize that without the observations the development of predictions would have been impossible and to recognize that the Assyriologists deny that the Mesopotamians were observing the heavens in the third millennium, meaning that the observations started with the Egyptians.

The Summary of the Astronomical Evidence

It is highly probable that the Mesopotamians originally developed the system of months and years as administrative conveniences at the end of the fourth millennium BCE. The Egyptians adopted the Mesopotamian calendar but then found a pragmatic means of solving the inadequacies of the Mesopotamian calendar by using observations and predictions of Sothis as a control. This observation was part of a complicated program of astronomical observations that included the discovery of the ecliptic and the recording of the movements of the planets.

At some point, the Egyptians lost a mastery of their own astronomical heritage. This was probably a direct result of the inadequacies of the calendar and meant that astronomy was eventually assigned to the realm of religion rather than science, as von Lieven observed. The Egyptians abandoned the scientific pursuit of the celestial, but by then they had named the planets with which they were familiar (Mercury, Venus, Mars, Jupiter, and Saturn, as well as the moon) after gods in a fashion that was adopted by all other civilizations from China to Rome. They also laid the foundations for the association of the movements of the planets with the fates of kings, which would dominate until the advent of the Indo-Europeans in the form of the Persians and the Greeks.

Religion

The development of science, religion, and magic is complicated, but the evolution of religion must be sketched to understand the complicated developments in the history of science. In Egypt, the "scientific" medical texts antedate the emergence of magic and religion as significant elements in Egyptian medical thought. Geller understands Babylonian medicine as having included "science" and "magic" from the start. Significantly, the earliest Sumerian incantation rituals date to the early third millennium BCE and are predominantly concerned with illnesses;[80] what might be early, Sumerian, medical recipes do not appear to differ from what came later in Mesopotamia. Thus, there would be no break, as in Egypt.

Significantly, it is probably only from the Ur III period onward that Mesopotamian myths began to be organized into coherent units, drawing on the literary sources of the incantation formulae and hymns.[81] In this sense, religion and magic will have existed prior to the emergence of Babylonian medicine, with medicine already dominated by magic. This contrasts with Egyptian medicine, and could explain the difference between the two.

In the case of astronomy, the Egyptian observations of the heavens seem to march hand in hand with the emergence of the religion, as Assmann has stressed for decades that myth emerged only relatively late in Egypt,[82] possibly even later than in Mesopotamia. The understanding of the heavens in the mid-third millennium BCE contributed to the formulation of the Egyptian concepts of an afterlife and to the emergence of religion. Magic followed later. Thus, one must distinguish between (a) the appearance of gods (which dates to the fourth millennium BCE or earlier) and (b) the appearance of myths (which date to the end of the third millennium BCE at the earliest) and relate these to (c) the growth of magic (primarily from the second millennium BCE onward) and (d) the emergence of science as a separate domain.

It is highly probable that the Mesopotamians and Egyptians shared concepts during the third millennium, among them the concept of associating the national gods with the celestial beings. The names chosen were those of the gods of the states, such as Thoth and Nanna-Suen/Sin for the moon. Being much younger, it is not surprising that the Greek goddess Selene never had a role of power. And indeed, although the powerlessness of the moon was already recognized in Mesopotamia by the beginning of second millennium, first millennium Assyrian kings would go on building and rebuilding monuments to Sin and Shamash (whom they hardly revered). In contrast to this, the Egyptian sun god Re retained his position long after the earliest Egyptian astronomical work had been forgotten.

Potentially significant is the meaning of Nanna-Suen's epithet, BABBAR, which is the same as Selene (Σελήνη), meaning "bright, luminous." More interesting is that somehow, the earliest sun gods, both Utu/Shamash and Re, were associated with legitimate power and justice, which are most assuredly attributes of states and not prehistoric peoples. And by the end of the third millennium BCE, both Shamash and Re are also associated with the balances that created the concept of "equilibrium" that is the basis of "justice."[83] Thus, the general interpretation of the celestial beings as powerful gods was born in early times, only to diminish over time so that Helios and Mercury are almost irrelevant even in classical mythology.

Only Mars and Venus live on into our own day. In antiquity, when these names were awarded, these were generally important gods in the state system of worship. Even if their importance was gradually eclipsed over time—as in the case of Sin in Mesopotamia—in the third millennium BCE they were central gods. Obviously, this "religious" aspect should also be borne in mind when approaching the matter of the historical validity of alleged observations.

In my view, eclipses will initially have been observed and related to the social life of this world before the concept of fictive eclipses (independent of observations) could be introduced. This is part of the history of religion. Since we have no evidence whatsoever for any advanced astronomy in Mesopotamia in the third millennium, it follows that the Ur III eclipse observations were probably not fictive— especially as they have been verified. This mode of reasoning would be typically Mesopotamian, as it links "scientific observation" to "religion" and thus gives meaning to the observation. For the Egyptians, the procedure was probably the opposite: the observations gave birth to the concept of the activities of the gods (as visible in the nightly heavens).

Both methods depend upon observation and interpretation. Without the first step (of observing and relating), the second (that of inventing eclipse observations so as to legitimate social interpretations or to develop omens that by definition could not take place) would have made no sense. The closer one is to the origins of astronomy, the more probable it is that documents record the first step: only later can fictive eclipses be introduced to match expectations or requirements. The Ur III omina may have been at the beginning of this process in Mesopotamia, with fictive events later. This process—from observations to predictions and fiction—will have taken a good part of the period from the beginning of the second millennium to the end of the first millennium BCE.

There may be another twist. Steele remarks that "[i]t is surely not mere coincidence that a surprising numbers of eclipses [sic] are said to have been seen during or on the eve of major battles in Antiquity."[84] Steele considers such coincidences improbable, but the situation may be exactly the opposite: clever commanders may have deliberately exploited expert knowledge to take advantage of a convenient eclipse precisely because it was widely believed that eclipses were indeed portents and could thus disconcert the unsuspecting, illiterate soldiers of an opponent. Such a procedure would have been far more valuable than inventing eclipses. Furthermore, such observations—in times of warfare—are more likely to have entered the historical records.

Thus the arguments about the religious interpretations of eclipses should be understood in a context taking account of the historical development of science and religion (and politics), rather than relegating all historical contexts into one group as if there was no development.

A Hint at Later Developments

Most significant is the history of the calendar. This practical device was essential for hunter-gatherers and farmers alike. Understanding the year as consisting of an irregular number of lunar months, each with an irregular number of days, would have encouraged most thinkers to abandon the idea of regularity. Yet the Mesopotamians evidently took the opposite approach, assuming that they could regulate the length of the month and year alike, in the sense that they decided the measures for length and volume arbitrarily. Having invented a mathematically impeccable calendar, for the rest of their history the Mesopotamians wrestled with intercalary months and lunar calendars without finding a fruitful solution to the length of the year. The Egyptians solved the problem by simple observation and left it at that. The real calendar approaching the length of the year, we probably owe to the Greeks, but there is that strange notation used by Sudines (mentioned below). Furthermore, if we follow the Assyriologists, it was only at some late date that the Mesopotamians began observing the stars and planets seriously and there remained a long interlude where religion, science, and magic were mixed before the birth of whatever Babylonian science we can elucidate. And this evidently came so late that it actually grew up in parallel with Greek science. In this sense, the Greeks probably established the length of the year around the time that they came into close contact with the Babylonians. Thus, if we follow the Assyriologists, Greek and Babylonian astronomy came of age at more or less the same time in the first millennium BCE and was thus quite late in reaching the level of observation that the Egyptians had reached in the third millennium BCE.

Significantly, however, the Egyptian documentation of the retrograde motion of the planets in the ecliptic could have played a role in theoretically anchoring the heliocentric version of the solar system. Discussions of the phenomenon of the retrograde motion of the planets in classical times are taken as indications of an understanding of the heliocentric solar system as advocated by Aristarchus of Samos (seconded by Seleucus of Seleucia, as well as others, possibly including Posidonius, Hipparchus, and Pliny). Ehlers relates Aristarchus's efforts to resolve the "anomalies" in the motion of the planets to his arguments for the heliocentric solar system.[85] Certainly, reflection based on the observation could have served as an argument against the geocentric version of the universe.

Yet the Egyptians seemingly did not make the leap to a theoretical analysis. Instead, from the beginning, their observations were carefully recorded and contributed to a description. In this sense, one could suggest that it was not Aristotle and Ptolemy who established the geocentric system, but rather the Egyptians. In any case, the system was so well anchored by the time that the Greeks and Babylonians adopted it that it was not overcome until recent centuries. By then the Egyptian observations were irrelevant, but they may have played a role in the formation of the theory in Hellenistic times, in which case the Egyptians were definitely on the right track and contributing to the development of theory through their observations.

Summary

The 12-month, 360-day year calendar was invented in Uruk toward the end of the fourth millennium BCE. This was based on good guessing and mathematics. The balance may have been invented in Egypt and diffused to Mesopotamia at roughly the time the Egyptians adopted the Uruk calendar. The balance was based on a concept of weight and led to the emergence of the concepts of "equivalencies" (by which quantities of grain could be assigned a value corresponding to a weight of wool or silver, etc.) and "equilibrium" (which was associated with "light" and "justice").

Egyptian astronomical observations probably began to be regularized around the middle of the third millennium BCE, after which the Egyptians adjusted their calendar. At the time of their emergence in the early second millennium BCE, Babylonian medicine and astronomy drew on the then contemporary Egyptian understanding of the world, which was a confused combination of religion and science resulting from the incapacity of the Egyptians to understand germs and the problems with their calendars. The Babylonians do not appear to have improved substantially on this until the first millennium BCE, when the Greeks were able to take over (and may have influenced Hellenistic Mesopotamian astrology).

Dating the Emergence of Science

It is hardly original to suggest that Egypt was considered by the Greeks themselves to have been a home of the sciences. Yet Western historiography has generally neglected this (presumably ascribing the Greek statements about the wisdom of Egypt to false modesty). In mainstream discussions, the dominance of preconceptions about the importance of Greek science has long prevailed.

Nevertheless, the general tendency to assume that the Greeks invented science is gradually breaking down, as confirmed with Rochberg's pushing the case of the Babylonians in a contribution confronting the prevailing arguments about the superiority of Greek science.[86] Although Egypt is constantly mentioned in Rochberg's article, Egypt is necessarily excluded from her discussion, which concerns the relative contributions of Greece and Mesopotamia. Yet Rochberg's contribution is typical in that the Assyriologists are gradually—if unintentionally—giving the impression that it was Mesopotamia rather than Egypt that was there before the Greeks.

Given this trend, it is hardly surprising that in Renn's history of the *Globalization of Knowledge* (which is actually a tale of the history of science rather than knowledge), there are three separate chapters on different aspects of ancient Mesopotamia.[87] Egypt, however, is not allowed a single slot, with the result that nothing of significance from Egypt is mentioned anywhere in the volume. One of the contributors to Renn's volume, Schiefsky, discusses Babylonian input into Greek thought and makes allusions to Egyptian contributions to Greek thought.[88] However, Schiefsky's concern is that the Greeks "borrowed" what he terms "first-order knowledge and concepts" from the Ancient Near East and, through reflection, developed what he terms "second-order knowledge." This latter is analytical, setting "out a conception or norm for what knowledge is in a particular domain."[89] In his framework, Schiefsky also allows "first-order-knowledge" to include what he accepts as theoretical concepts. Thus, in fact, Schiefsky allows the Egyptians and Babylonians to develop theoretical knowledge but seemingly concludes that real abstract concepts appeared in only the Greek world. In this sense, Schiefsky is pleading for an evolution in ancient scientific thought.

In contrast to this, Renn remains firmly convinced that modern science did not emerge from ancient science, but rather that modern science is qualitatively different from what was undertaken in the ancient world. This effectively undermines the significance of Schiefsky's major contention in Renn's volume, namely that the Greeks consciously reflected on the meaning of the observational data they acquired from the Babylonians and thus developed a new approach. Part of Renn's strategy is to suggest that what he effectively understands as the "globalization of ancient science" took place after antiquity as the Arabs translated the Greek texts and these became available to the Europeans in the Middle Ages and Renaissance.[90] In this fashion, interaction in the development of scientific methodology and knowledge in antiquity is simply disregarded or dismissed. Renn thus contends that "modern science was more an outcome of the globalization of ancient knowledge rather than its renaissance."[91] By suggesting that modern science differed so radically from Greek science (which itself formed part of a diffusion process in antiquity), Renn is effectively contradicting some of the contributors to the volume.

Renn's object was, of course, primarily meant as a blow against Greek science, which was long viewed as having been fundamentally different from ancient Near Eastern work in any case, as, e.g., Schiefsky contends. Changing the relations by conceding a more substantial role to the Babylonians in a venture that is alleged to be basically irrelevant to historians of science does not change the fundamental argument in favor of dismissing the relevance of ancient science. Yet one significant consequence is that, through neglect and denial, the procedure effectively dismissed the significance of the scientific work of the Egyptians in a two-fold fashion. And it also excluded the idea of international scientific discourse having taken place in antiquity despite the fact that such contacts are demonstrated by the very renown of Egyptian physicians abroad.

Understanding the History of Science

Most Egyptologists would probably contend that the ancient Egyptians made major contributions to the foundations of science but would probably also be at a loss to explain in detail just how this fits into the grand narrative of the history of science, since the Egyptian material is embedded is a social context that discourages us from claiming "pure science." This is indeed a severe handicap, especially so since the prevailing discourse tends to dismiss all forms of "superstition" and is reluctant to recognize "science" where "divination" might be the correct label, as the Assyriologists have more or less accepted. The consequence is that claims to scientific practices in Mesopotamia are increasingly restricted to the first millennium BCE, with the paradoxical consequence that Babylonian science ceases to antedate Greek science in a significant fashion.

And this leaves a yawning gap where the origins of science should be found. My claim is that the Egyptians might aid in filling that gap, especially if the Assyriologists are unwilling (a) to make claims for scientific work in the third millennium BCE and equally unwilling (b) to abandon their claims that divination and science were always confounded in Mesopotamia. The major issue is therefore persuading mainstream historians of science that the Egyptian material deserves attention. Socrates and the Pre-Socratics are somehow viewed as having potentially legitimate claims for inclusion in the tale.[92] Near Eastern pre-Greek history is somehow disconnected, with some allowances made for the Babylonians but little more. The fact that Martin Bernal seems to be the only person permitted to publish a piece on Egypt's contribution to science in *Isis*—one of the outstanding journals on the history of Science, named after a celebrated Egyptian goddess—is hardly a promising portent hinting at an accommodating reception to a discussion of Egypt's potential contributions.[93]

One important challenge is thus overcoming the current general prejudice against Egypt. This is largely a matter of marshaling the facts and presenting the documentation in a fashion that can be understood by non-specialists. Another problem is distinguishing between religion and science, facing the reality that much of what we call "science" is preserved in religious and administrative texts. Yet the Mesopotamian and Greek sources are also suspect in their own ways, as the debate about the Ur III lunar eclipses and Thales's eclipse prediction reveals.[94] But only facing these issues and pulling out the relevant examples will allow the entire history of science to be reconstructed.

It is futile to dismiss the Greek debates about the nature of the "geo-system" (as opposed to the Renaissance "solar system") as not having been major contributions to science. Yet there is that vast experience of observation which the Bronze Age bequeathed to the Greeks, and this can hardly be dismissed, any more than one can dismiss Stonehenge or potential observations of lunar phases in the Palaeolithic, as even NASA is willing to discuss it (even if the historians of science are not).[95]

I suggest that most of the attention has been awarded to the ascent of the higher rungs of the ladder leading to modern science. However, it is frequently forgotten that, aside from the lower rungs, there are also the stabilizing sidebars, forming the framework into which the rungs are fitted. In the Bronze Age, the Egyptians and Mesopotamians developed methods of observing, recording, describing, and interpreting various phenomena, establishing the basic framework for the emergence of science, without which the subsequent procedures would have had no meaning. Their observations and interpretations contributed to creating a platform for debate. Without written records, it would have been impossible for Stonehenge to be decoded. Thus the ancient Near Eastern literary legacy of observations is the foundation of the tradition upon which modern science is based, and this served as the basis for the Greek debates. And those Greek discussions—as mistaken, incomplete and dissatisfying as they are—were themselves a major step, one to which the Arab commentators made their contributions, inspiring and encouraging Europeans to continue the discussion.

One of the most important developments in the history of philosophy took place in the centuries before the Common Era: the invention of a type of logic that could exclude one premise by demonstrating evidence confirming that another premise was correct, based upon empirical experience. This discovery was rendered insignificant as the Roman Empire seems to have brought a halt to scientific analysis, and the concept of logic itself was transformed and rendered irrelevant by the Christian concept of faith. Monotheistic concepts of faith undermined logical argumentation by denying its relevance, and thus Islam did not rely on a system of logic that could propel scientific thought far beyond the thought of the classical Mediterranean.

While the West lost a great deal of early science, logic and argument survived, meaning that a relatively distinct type of thought was preserved as urbanism and literacy spread with the late Middle Ages. By the end of the Middle Ages, Europe had reached a point where the Renaissance and the Enlightenment were able to build on the earlier accomplishments and extend these to create modern science during the Industrial Revolution. Developments in late Medieval Europe began the slow but steady acceleration of thinking and technological development that took Europe on a route allowing it to overtake what China (and all others) had accomplished.

Those medieval developments were founded upon what took place before, namely what classical antiquity had bequeathed to the world. Obviously, it is not excluded by anyone that Egypt and Mesopotamia will have influenced the classical world.

Rather than dismissing the Greeks, one could flow with the prevailing current and turn to the era before the Greeks, to be (a) in a better position to understand what was remarkable about Greek thought, and (b) to recognize and understand all of the steps that have led to modern science. Ultimately, we can (c) only grasp what modern science is, if we understand whence it came.

Science is somehow associated with "truths," but not cultural, social or philosophical truths so much as "enduring, eternal, absolute truths" that are universally valid and usually relate to that natural universe. According to our current understanding, but necessarily oversimplifying, "science" is (a) "accumulated" (true) knowledge, (b) the "pursuit" of true knowledge, and (c) a "method" of separating (1) "assumptions" and "commonplaces" from (2) "scientifically defined certainties." Judging the degree to which individual and institutional practitioners in the past discriminated "scientific activity" from other activities is probably impossible: we can only judge the activity in the past based on the methodology and the results and compare these to our expectations. If certain records of events (e.g., eclipses) or regularities (e.g., the paths of planets or stars), which "modern scientific means" can confirm took place as described, demonstrate observation and recording of events or regularities in the past, then I would say that those engaged in this activity were pursuing science. It is probably pointless to try to distinguish (a) the motives (religion, finance, prestige, power, etc.) that drive scientists from (b) their methodology. Understanding how science emerged cannot be based on arbitrary assumptions about what underlies "scientific" activity, thus excluding certain participants from participation in the process. The only result of such exclusionary processes is that science would "suddenly" lie before us: either in Babylon, classical Greece, the Renaissance, the Enlightenment, or the Industrial Revolution, depending upon the position of the observer and his criteria. In each case, it will be argued that this "new science" lacks serious predecessors, as each of the alleged predecessors lacks that one thing that defies "science" according to the author in question. The mere fact that such interpretations are possible confirms the subjective nature of the means of judging "science" as the history of science is currently conducted.

I merely argue that Egypt had a very important role in the early developments since the Egyptians made systematic observations (both in medicine and astronomy) that apparently allowed them to draw some early conclusions about the universe. However, the Egyptians were not alone, and it is possible that some of the blank spaces in the history of science can be filled in only by relating developments in one region with those in another. We must entwine the strands of the Egyptian contribution into the main narrative.

Mainstream work tends to assume that the Greeks learned most of what little they received from abroad from the Babylonians. Furthermore, it is known that, chronologically, certain astronomical concepts are documented only during the final centuries BCE in the Greek and Babylonian sources.[96] Thus, there may have been more Greek influence on Babylonian astronomical thinking than has generally been allowed, but the trend is that ancient science remains the preserve of the Greeks and the Babylonians. This opens the way for a relatively linear evolution of scientific thought from the Sumerians and Babylonians to the Greek and the Arabs. In this streamlined narrative the Egyptians did not play any significant active role, i.e., whatever the Egyptians did allegedly failed to leave a mark.

Yet the sources abound with curious items, such as a case where Rochberg cites the Babylonian Sudines as having defined a year as "365 + ¼ + ⅓ + ⅕ days, which makes no astronomical sense."[97] In fact, the notation looks suspiciously Egyptian and definitely includes a scribal error of some undeterminable kind. Yet this actually could nevertheless be quite interesting as a year with a fraction more than 365.25 days would take us very close to a sidereal year. Since the sidereal year is judged by reference to fixed stars—where the Egyptians were certainly early authorities in observation—such a figure could have been established simply based on their ordinary observations. Thus, one has the impression of encountering a source that could be of momentous importance, as it implies that the Egyptians may have stumbled upon a figure not far from the actual length of the year at some point and that this calculation was known to the Babylonians—but the matter is dismissed.[98]

Thus the real meaning is that Egypt is excluded by neglect rather than argument. Although there are occasional exceptions to the rule that Egyptian influence is excluded, the general approach validates this attitude. Here I try to briefly summarize my view of the situation and propose that the Egyptians did make profound contributions to the development of science, particularly in the matter of observation, which played an important role in both astronomical and medical procedures. Yet the development of science may have involved more give and take than might be apparent at the outset and is further complicated by ideological positions held by historians of science.

Observations

Whereas the general tendency today is to propose that most early science was Mesopotamian and Greek, I would argue that one can point to Egyptian origins of science in the sense of observation. The concept of deducing from observations and using observation as a means of controlling predicted consequences are as basic to modern science as is the use of mathematics. This would enhance the meaning of the early Egyptian contributions if one could place them in perspective.

Thus I argue that, in the cases of astronomy and medicine, the Egyptians began with a serious confrontation with the data sometime during the third millennium BCE, and that the Babylonians began a millennium later, but on a far less scientific basis. I would argue that Egyptian medical activity began in a context that was not riddled with magic, as is the case with later Egyptian and Babylonian medicine. By contrast, the Egyptian confrontation with astronomy probably contributed to the emergence of religion as a phenomenon and one that also had an impact defining the limits of Mesopotamian astronomy. I would also stress that Egyptian practice in astronomy and medicine is based upon observation and analysis. The Mesopotamians may have later contributed significantly to astronomy with their mathematical models, but the earliest mathematical efforts that created the 360-day year may have actually adumbrated the limits of a method that made the approach a dead-end alley rather than an opening.

Without the long tradition of recorded observations, calculating the regularities that gave birth to mathematical astronomy would have been impossible. Enduringly relevant successful theoretical insights cannot be based on a small slice of data. This is the point of Couprie's solution "to explain why Thales predicted one, and only one, solar eclipse": "Thales might have been deluded by an apparent though non-existing regularity."[99] To overcome this obstacle one needs centuries of observations, and these were first done in Egypt. Thales was trying to predict irregular events based on an inadequate data set; the Egyptians were simply observing and establishing recurring patterns. Understanding that—and how—others have taken this forwards is precisely the point of the history of science.

Evidently, observing and predicting were part of traditions developing in third millennium BCE Egypt. This is evident from the diagnosis whereby a physician could imagine that he could treat an injury as well as the procedure by means of which a date for the heliacal appearance of Sothis could be predicted, quite aside from the fact that the Egyptians developed festival calendars based on the reappearance of the various phases of the moon. In this sense, the third millennium BCE Egyptians were engaging in science in the sense specified by Neugebauer and were certainly well ahead of the Mesopotamians.

Relations between Religion and Magic

While gods and myths seemed to have marched in parallel in Mesopotamia and Egypt, magic had its own history—and science fell victim to magic, rather than magic preventing the growth of science. Yet, there is also the slight matter that Egypt seemingly underwent a phase not recognized in the Mesopotamian records: that the observations of the movements of the celestial bodies in the ecliptic were expressed in religious terms, but basically descriptive ones. The Assyriologists suggest that Mesopotamia did not have such an era, but rather that science and religion were mixed together without a preponderance of science until the first millennium BCE, by which time religion was taking its toll on Egyptian science. In this sense, the interaction of science and religion seems to have been quite complicated in the millennia before the Greeks began a scientific discourse.

According to this interpretation, Egyptian science emerged together with religion, whereas in Mesopotamia religion and science were mixed from the start. In the opposite sense, the unreliability of the calendar and the incomprehensibilities of microbes led to despair about the "scientific" interpretations in Egypt, whereas somehow in Mesopotamia a kind of astronomy with scientific features began to develop despite the magic, religion, and astrology. Given (a) the lack of a philosophical discourse and (b) the inadequacies of the available methods to offer means of reconciling the incomprehensible realities (theoretical and empirical), science was overcome by magic and religion in both Egypt and Mesopotamia.

By the Hellenistic Era, religion had long overtaken science in Egypt and thus it was impossible to build on the accomplishments of the Egyptians until Christianity began to crumble, by which time the discoveries of the Ancient Egyptians had been forgotten. Only with the renaissance could the tale be continued and only in the West.

Relations between "Science" and "Bureaucracy"

It is true that Western science did emerge from the ruins of divided Christendom, and in this sense it is frequently assumed that "religion" was responsible for the earlier failure of science to break out. As noted, the Assyriologists are in the strange position of being relatively certain that somehow astronomical science did emerge in a highly religious world. And most classicists would agree that the Hellenistic world was also a religious world. Yet it was not in Greece but rather under the Roman Empire that science really died (or went into that long sleep that was so vital to the success of Christianity).

In this context, it is worth noting that in China it was not a single religion so much as a bureaucracy that impeded the advance of science, both internally and externally (with regard to the Jesuits). At that time, in contrast to today, the Chinese bureaucracy was probably unconscious of the possibilities of economic development transforming a society and viewed their own understanding of the universe as adequate. Today, however, that bureaucracy has changed its attitudes toward economic development, and since science is closely associated with technology and economic development, that bureaucracy is embracing science.

Thus bureaucracies—such as those in the Berlin, Constantinople, London, Paris, the Vatican, or Beijing—can decide the fate of science. That what we would call religious motives could be among the reasons for hindering scientific development, but this was really only true in the West, which was the only region to develop what we call modern science. Thus, although widely assumed, it is not clear that religion was the stumbling block. Regardless, it should not be forgotten that bureaucracies (whether in Beijing, Delhi, Detroit, Seattle, Silicon Valley, or Washington) cannot only hold science back but also push science onward—and mostly for pecuniary reasons.

Relations between "Science" and "Economics"

While the relations between science and religion are generally used to dismiss ancient science, modern scholars should be very wary of assuming (a) that they understand what was going on in the ancient world and (b) that modern science is an independent phenomenon merely contributing haphazardly to "scientific" discoveries.

Ebenstein, in his biography of von Hayek, cited Joseph A. Schumpeter as having stated, "Human needs are the driving force of the economic mechanism." Given Schumpeter's conviction that a cyclical process of creative destruction based on technological innovations was the key to understanding economic development, this meant that the need to acquire new innovations would drive the economy onward, pushing technological innovation.[100] Both Schumpeter and Hayek belonged to Menger's[101] Austrian theoretical school of economics that defeated the historical schools of economics in the nineteenth century. Ebenstein himself summarized the Austrian view that economics "ultimately concerns the satisfaction of human wants, needs, and desires, and the highest material standard of living, which requires the most scientific knowledge."[102]

This is a highly theoretical model, and it has contributed to our modern ideology: that science serves the creation of the highest material standard of living. Economists make economic growth in advanced economies dependent upon technology; a Nobel Prize winner and distinguished central banker confirm: "In countries on the leading edge of technology, the advance of knowledge is a key determinant of growth."[103] This is the virtuous link by means of which science (understood as "knowledge"!) pushes economic growth through technology.

It is for this reason that we encounter discussions of "ancient science" in books otherwise dedicated to technology, even though there is virtually no technology to be found in the relevant chapters (such as, e.g., Neugebauer's chapter in *A History of Technology*)[104] or likewise articles on "technology" in economic histories (such as, e.g., Schneider's chapter in *The Cambridge Economic History of the Greco-Roman World*).[105] As a result of such tendencies, the entire educational system of the modern world is being gradually transformed into a service center for the needs of industry because of an ideology dedicated to ever expanding economic growth assumes that science pushes prosperity.

Yet the reality in the ancient world at least is rather different. Even Helmut Schneider, one of those who has championed Roman technological innovation, would have difficulty supporting Schumpeter: paradoxically, while proclaiming that there were Roman technological innovations, he denies that technological innovations played a significant role in economic growth[106] and yet concludes that "considerable extensive growth took place."[107] Significantly, Yener has demonstrated that Anatolia had extremely sophisticated metallurgy in the third millennium BCE,[108] yet the wealthiest parts of the world were Egypt and Mesopotamia, which imported the goods. Regardless of the evidence, archaeologists tend to assume that the most advanced civilizations had to have the highest technology.[109] The science of the wealthy peripheral states was a low-technology pursuit of knowledge: astronomy, mathematics, medicine. The technology of the ancient periphery was a practical hit-and-miss affair carried out by craftsmen, and this lasted until well into the nineteenth century CE. Evidently, before the modern era technological innovation was not related to, nor responsible for, scientific development or economic growth.[110]

The key to understanding the conundrum is that the pharaohs and the rulers of Mesopotamia will have thought differently about the goal—i.e., not understanding economic growth so much as increasing their wealth and power—but they did harness science for their own purposes. And their means will have been the same as in the modern era: funding the bureaucrats responsible for knowledge. These bureaucrats will have developed a science that met the needs of their masters and thus expressed themselves in suitable terms. That modern scientists respond to the same incentives with the same results should hardly be surprising. Ever since that distant time of the Near Eastern Early Bronze Age, scientists have always been particularly susceptible to the attractions of funding.

Whether any of this was ever of any use to the gods, rulers, or ruled could be debated, but in antiquity and today, it turns out to be good for the scientists (at least materially, because material attractions may impair their scientific endeavors).[111] Thus the public in the modern era may benefit as little as did the people, gods, and kings of the ancient world, but scientists flourished and flourish under the protection of their sovereign funding.

Modern science is a product of state and private investments, investigating those questions that the powers that be (private or state) are willing to fund. Certainly whatever we know of ancient science from Mesopotamia was state-supported or market-supported and not a matter of the free search for knowledge. The hard sciences benefit from state support today, but even more important is the concession by the economists that economic growth is assigned to technology (rather than exchange, labor, economics or money). In this sense, through the development of technology, science serves the market. And by delivering a constant stream of innovative products to those who have money, it contributes to "economic growth;" that this is both circular logic and a tautology does not make it less true.

However, it is entirely possible that the situation is more complicated and that, in reality, through late nineteenth century CE technology and modern economic theory, science was saved from being dominated by conflicts with religion and magic. Yet, nevertheless, the role of science in serving the modern economy should be at least as suspect as the role of ancient science in serving religion. In this sense, one should simply bear in mind that science always functions in a real social world, and that this reality should not allow one's own prejudices to influence one's capacity to judge whether a given reality is or is not science. It would probably be far more rewarding to examine and explore the nature of Bronze Age religions[112] than to dismiss ancient science because of associations with religions which we do not really fully understand.

The Contributions to Science

Thus, I argue a long tradition whereby astronomy and medicine developed from the Bronze Age onward. The Egyptians, Babylonians, and Greeks made important contributions that fed into what was transformed in Europe during the late Middle Ages and Renaissance. With the Enlightenment and the Industrial Revolution, the pace of scientific progress accelerated by several orders of magnitude. It is a fact that this took place in the European (or Western) world, and that this Western world left the rest behind. It is also true that it was this modern Western world that left the rest of the world behind economically as well, meaning that science, technology, and economics move hand in hand today, whereas ancient science was associated with religion.

It inevitably follows that modern science differs by several orders of magnitude from ancient science. However, without the precursors modern science could not exist. Certainly, one of the most important developments was the concept of a methodological logic that could allow the exclusion of various possibilities. This was debated in antiquity and perfected in the modern West. However, the basis for the very concept was a choice of alternative explanations, and those explanations depended upon alternative interpretations of observations. Without those observations and interpretations (which had been developing throughout and since the Near Eastern Bronze Age), there would have been no basis for developing logic and methods of exclusion. None of this was evident: each step at every stage had to be discovered and developed.

Given the undisputable chronological priority of Egypt in the development of astronomy and medicine, one should not allow the Egyptian contributions to be marginalized by neglect. Spalinger implies that Egyptologists are occasionally too hasty when trying to draw attention to ancient Egyptian contributions to science in the ancient world.[113] This is not only ill advised but also superfluous, since the dates given by the Assyriologists assure the Egyptian priority. Given the chronological priority that by default the Assyriologists assign to ancient Egypt, there should not be any kind of discussion about where the origins of Babylonian astronomy and medicine should be sought. In the second millennium BCE, the Mesopotamians will have been able to draw on Egyptian experience when developing their own science.

Yet the story of science is hardly short of complicated changes, such as the importance of magic, religion, and economics. Somehow, Mesopotamian calendrics were adopted in primitive Egypt and refined to the extent that a complicated ideology based on astronomical observations emerged in the third millennium. Thus, Egyptian science contributed to Egyptian religion and probably Babylonian thought, and somehow Babylonian astrology gave birth to Babylonian astronomy while Egyptian science withered away. Magic and superstition came to dominate thought during the Roman Empire, culminating in the triumph of the monotheistic religions. Yet, somehow the germs of these various traditions were sufficient to be harnessed for economic purposes late in the nineteenth century CE, and this led to a real transformation of science. Isolating one particular era, nation or tradition as having created science is as imbalanced as denying the complications.

One can dismiss my argument. However, it is not entirely clear to me that those casting it aside can actually produce an adequate alternative account of the nature and history of science without Egypt that is both in accord with the facts and free of contradictions, unjustified assumptions, and irrelevant conditions. And that is probably just as important as my account.

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1 John Steele, *Observations and Predictions of Eclipse Times by Early Astronomers* (Dordrecht: Kluwer Academic 2000): 24.

2 If in a slightly questionable way, e.g., Homer, *Odd*. IV: 231-232.

3 Elmar Edel, *Ägyptische Ärzte und ägyptische Medizin am hethitischen Königshof* (Opladen: Westdeutscher Verlag, 1976).

4 Elmar Edel, *Die ägyptische-hethitische Korrespondenz* (Opladen: Abhandlungen der Rheinisch-Westfälischen Akademie der Wissenschaften, 1994): 178–179; cf. also Trevor Bryce, *Letters of the Great Kings of the Ancient Near East* (London: Routledge, 2003): 123.

5 See James H. Breasted, *The Edwin Smith Surgical Papyrus* (Chicago: University of Chicago Press, 1930).

6 Markham J. Geller, *Ancient Babylonian Medicine: Theory and Practice* (Oxford: Wiley-Blackwell, 2010): 59.

7 Geller 2010, 9.

8 Bryce 2003, 126.

9 Gerd Graßhoff in Jürgen Renn (ed.), *The Globalization of Knowledge in History* (Berlin: Max Planck Research Library, 2012): 176.

10 E.g., John M. Steele, "The Use and Abuse of Astronomy in Establishing Absolute Chronology," *Physics in Canada* 59 (2003): 243–248; John M. Steele, "A Comparison of Astronomical Terminology, Methods and Concepts in China and Mesopotamia, with Some Comments on Claims for the Transmission of Mesopotamian Astronomy to China," *Journal of Astronomical History and Heritage* 16 (2013): 250–260.

11 Joachim F. Quack, "Die Klagen über die Zerstörung Ägyptens. Versuch einer Neudeutung der ‚Admonitions' im Vergleich zu den altorientalischen Städteklagen," in Beate Pongratz-Leisten, Hartmut Kühne and Paoloa Xella (eds.), *Ana šadî Labnāni lū allik: Beiträge zu altorientalischen und Mittelmeerischen Kulturen* (Neukirchen-Vluyn: Neukirchener, 1997), 345–354.

12 Jonathan M. Kenoyer, "Measuring the Harappan World," in Ian Morley and Colin Renfrew (eds.), *The Archaeology of Measurement* (Cambridge: Cambridge University Press, 2010), 106–121.

13 Marvin A. Powell, "Masse und Gewichte. §V. Sumerian and Babylonian Weight Measures," *Reallexikon der Assyriologie* 7 (Berlin: de Gruyter, 1987–1990), 508–517.

14 Cf. Josef Bauer, Robert K. Englund, and Manfred Krebernik, *Mesopotamien: Späturuk-Zeit und Frühdynastische Zeit* (Freiburg: Universitätsverlag, 1998), 118, 305.

15 E.g., Tanja Pommerening, "Weights and Measures, Pharaonic Egypt," in Roger S. Bagnall et al. (eds.), *The Encyclopedia of Ancient History* (Oxford: Blackwell, 2013), 7087–7092; Carlo Zaccagnini, "The Dilmun Standard and Its Relationship with Indus and Near Eastern Weight Systems," *Iraq* 48 (1986): 19–23.

16 Hans W. Müller, "Neuerwerbungen der Staatlichen Sammlung Ägyptischer Kunst," *Münchner Jahrbuch der Bildenen Kunst* 21 (1970): 185.

17 James E. Quibell, *Excavations at Saqqara 1911–1912: The Tomb of Hesy* (Cairo: Service des antiquités, 1913), pl. XVI.

18 David A. Warburton, "Prices and Values: Origins and Early History in the Near East," in Kristian Kristiansen, Thomas Lindkvist, and Janken Myrdal (eds.), *Trade and Civilization* (Cambridge: Cambridge University Press, forthcoming).

19 Englund 1998.

20 Robert K. Englund, *Organisation und Verwaltung der Ur III-Fischerei* (Berlin: D. Reimer, 1990).

21 Anna Michailidou, *Sidelights on Measurement from the Aegean and the Orient* (Athens: de Boccard, 2008).

22 Joseph Needham, Wang Ling, and Kenneth G. Robinson, *Science and Civilisation in China IV: 1* (Cambridge: Cambridge University Press, 1962), 17 cite the *Huai Nan Tzu* referring to "balance" and "steelyard" toward the end of the first millennium BCE (contra Schemmel in Renn 2012: 272). However, earlier Chinese documents (and the coins) make it probable that the balance was known much earlier.

23 Renn 2012: 96.

24 Adriaan De Buck, *The Egyptian Coffin Texts V* (Chicago: University of Chicago Press, 1954): 321 has a reference to the "balance of the Sun-god Re," "weighing," and "justice;" Gustavus A. Eisen, *Ancient*

Oriental and Other Seals (Chicago: Oriental Institute Publications 47, 1940), pl. VI, 42 has a seal with a balance before the Mesopotamian sun god Shamash; Wilfried G. Lambert, *Babylonian Wisdom Literature* (Oxford: Clarendon Press, 1960), 121–138 has a hymn to the Mesopotamian sun god Shamash mentioning "balances" and "honest merchants." Thus, the link between the sun god, balances and justice was widespread in the Near East shortly after the invention and development of balances, before the beginning of the second millennium BCE. Of course, it was later Osiris, Horus, Thoth, and Anubis who were the main figures in the New Kingdom *Book of Dead* scenes of judgment, with Re less relevant. Yet Re's concern with justice is also evidenced in the Middle Kingdom *Coffin Text* Spell 1130, and in the context of this argument here, the key point is the shared responsibility of the respective sun gods Re and Shamash for justice near the beginning of the second millennium BCE, at the latest.

25 Geller 2010, 22.

26 Breasted 1930, I: xiii.

27 Breasted 1930, I: xiv.

28 Breasted 1930, I: 36.

29 Charlotte E. Green, "A Survey of Palaeopathogies in Human Remains and Medical Papyri from Ancient Egypt" (unpublished MA thesis, Yale University), 94–95.

30 Geller 2010, 22.

31 Rainer Hannig, *Großes Handwörterbuch Ägyptisch—Deutsch (2800–959n v. Chr.)* (Mayence: von Zabern, 2006), *s.v. wḫdw*.

32 One significant exception is Anne E. Austin, *Contending with Illnesses in Ancient Egypt* (hitherto unpublished Ph.D. dissertation, University of California Los Angeles, 2014). She is persuaded that the Egyptians understood contamination and discusses germ theory but, probably rightly, draws back from farther-reaching conclusions about their scientific understanding. Yet there is room for debate about the degree to which the Egyptians were approaching an understanding of diseases. Here it could be argued that the contemporary technology was inadequate for answering the questions even if the questions had been posed.

33 Noel M. Swerdlow, *The Babylonian Theory of the Planets* (Princeton: Princeton University Press, 1998), 181.

34 In Renn 2012, 176.

35 Graßhoff in Renn 2012, 177.

36 Graßhoff in Renn 2012, 188.

37 Otto Neugebauer, "Ancient Mathematics and Astronomy," in Charles Singer, Eric J. Holmyard, and Alfred R. Hall (eds.), *A History of Technology I* (New York: Oxford University Press, 1954), 798.

38 Dirk L. Couprie, "How Thales Was Able to 'Predict' a Solar Eclipse without the Help of Alleged Mesopotamian Wisdom," *Early Science and Medicine* 9 (2004): 321–337

39 Bernard R. Goldstein, review of *Observations and Predictions of Eclipse Times by Early Astronomers*, by John Steele, *Isis* 94 (2003): 136.

40 Rochberg 2010: 146.

41 Otto Neugebauer, "On Some Aspects of Early Greek Astronomy," *Proceedings of the American Philosophical Society* 116 (1972): 251.

42 E.g., Eckart Frahm, "Zwischen Tradition und Neuerung," in R. G. Kratz (ed.), *Religion und Religionskontakte im Zeitalter der Achämeniden* (Gütersloh: Chr. Kaiser, 2002), 74–108.

43 Robartus J. van der Spek, "The Babylonian Temple under Macedonian and Parthian Domina-tion," *Bibliotheca Orientalis* 42 (1985): 541–562.

44 Heather D. Baker, "Temple and City in Hellenistic Uruk," in Elizabeth Frood and Rubina Raja (eds.), *Redefining the Sacred* (Turnhout: Brepols, 2014), 192.

45 Alexandra von Lieven, *The Carlsberg Papyri 8. Grundriss des Laufes der Sterne: Das sogenannte Nutbuch* (Copenhagen: Museum Tusculanum Press, 2007), 295.

46 Hermann Gasche, James A. Armstrong, Steven W. Cole, and Vahe G. Gurzadyan, *Dating the Fall of Babylon* (Ghent: University of Ghent and the Oriental Institute of the University of Chicago, 1998).

47 Johannes Koch, "Neues von den Ur III-Mondeklipsen," *Nouvelles Assyriologiques Brèves et Utilitaires* 4 (1998).

48 John M. Steele, J. F. Richard Stephenson, and Leslie V. Morrison, "The Accuracy of Eclipse Times Measured by the Babylonians," *Journal for the History of Astronomy* 28 (1997): 343.

49 Steele 2003: 247.

50 Steele 2013 ("Comparison"): 250.

51 Brack-Bernsen and Steele 2005: 181.

52 Brack-Bernsen and Steele 2005: 181.

53 Brack-Bernsen and Steele 2005: 182.

54 John M. Steele, public lecture, Berlin, 10 December 2013.

55 Richard A. Parker, "Ancient Egyptian Astronomy," *Philosophical Transactions of the Royal Society of London. Series A, Mathematical and Physical Sciences* 276 (1974): 53.

56 Von Lieven 2007, 223.

57 Rolf Krauss, *Astronomische Konzepte und Jenseits-*

vorstellungen in den Pyramidentexten (Wiesbaden: Harrassowitz, 1997), 63.

58 Krauss 1997, 48.

59 Krauss 1997, 62.

60 E.g., Krauss 1997, 251, figs. 15a, 15b.

61 James P. Allen, review of *Astronomische Konzepte und Jenseitsvorstellungen in den Pyramidentexten*, by Rolf Krauss, *Journal of Near Eastern Studies* 61 (2002): 63.

62 Juan A. Belmonte and Mosalam Shaltout (eds.), *In Search of Cosmic Order* (Cairo: Supreme Council of Antiquities Press, 2009).

63 Kate Spence, "Ancient Egyptian Chronology and the Astronomical Orientation of Pyramids," *Nature* 408 (2000): 320–324.

64 As Andrew J. Shortland and Christopher Bronk Ramsey (eds.), *Radiocarbon and the Chronologies of Ancient Egypt* (Oxford: Oxbow, 2013), 287 concur with Erik Hornung, Rolf Krauss, and David A. Warburton (eds.), *Ancient Egyptian Chronology* (Leiden: Brill, 2006), 491 on the possibility that Khufu ascended the throne before 2500 BCE.

65 Otto Neugebauer, "The History of Ancient Astronomy Problems and Methods," *Journal of Near Eastern Studies* 4 (1945): 5.

66 Neugebauer 1954: 798.

67 Rolf Krauss, "Lunar Dates," in Hornung et al. 2006, 395–431.

68 Thomas Schneider, "Das Ender der Kurzen Chronologie," *Ägypten und Levante* 18 (2008): 292 quotes Christopher J. Bennet, review of *Ancient Egyptian Chronology*, edited by Erik Hornung, Rolf Krauss, and David A. Warburton, *Bibliotheca Orientalis* 64 (2008): 114–122.

69 Englund 1998, 121.

70 Alan H. Gardiner, *Egyptian Grammar* (Oxford, Oxford University Press, 1957), 303.

71 Richard A. Parker, *The Calendars of Ancient Egypt* (Chicago: University of Chicago Press, 1950); Parker 1974.

72 In Anthony Spalinger (ed.), *Revolutions in Time*. (San Antonio: van Siclen, 1994), xi.

73 Neugebauer 1945: 5.

74 Obviously, the principal objection here will be the proposition that the Egyptians invented writing some time before or at the same time as the Mesopotamians and that the Egyptians were not following the Mesopotamians. This argument is dependent upon Dreyer's interpretations of the radiocarbon dates for Abydos tomb U-j. In fact, the dates do not support Dreyer's arguments (for which cf. David A. Warburton, "Egyptian History: Definitely! Myth as the Link between Event and History," in Martin Fitzenreiter [ed.], *Das Ereignis* [Berlin: Golden House, 2009], 297–298). The Egyptian introduction of writing clearly followed the Mesopotamian invention of writing, for the Mesopotamian invention preceded the *ante quem* C-14 dates of ca. 3500 BCE while the Egyptian invention followed *post quem* dates of ca. 3300 BCE.

75 Gerald S. Hawkins, *Stonehenge Decoded* (New York: Doubleday, 1965).

76 For details, cf., e.g., Spalinger 1994 and Leo Depuydt, "Sothic Chronology and the Old Kingdom," *Journal of the American Research Center in Egypt* 37 (2000): 161–186.

77 P. Berlin 10012a, verso; cf. Ulrich Luft, *Die chronologische Fixierung des ägyptischen Mittleren Reiches nach dem Tempelarchiv von Illahun* (Vienna: Österreichische Akademie der Wissenschaften, 1992), 54–58; the prediction is easily consulted in Kurt Sethe, *Ägyptische Lesestücke* (Darmstadt: Wissenschaftliche Buchgesellschaft, 1959), 97: 1, but Sethe did not give the date of the letter, which confirms that it is a prediction. This date confirming a prediction is supplemented by the later entry for the offerings, for which cf. Rolf Krauss and David A. Warburton, "The Basis for the Egyptian Dates," in David A. Warburton (ed.), *Time's Up!: Dating the Minoan Eruption of Santorini* (Athens: Danish Institute at Athens, 2009), 135–137.

78 Neugebauer 1954: 793.

79 Neugebauer 1954: 798.

80 Cf. Nadezda Rudik, *Die Entwicklung der keilschriftlichen sumerischen Beschwörungsliteratur von den Anfängen bis zur Ur III-Zeit* (unpublished PhD dissertation, Jena, 2011).

81 Bendt Alster, "Variation in Sumerian Myths," in Fredrik Hagen et al. (eds.), *Narratives of Egypt and the Ancient Near East* (Louvain: Peeters, 2011), 55–79.

82 Jan Assmann 1977, "Die Verbogenheit des Mythos in Ägypten," *Göttinger Miszellen* 25 (1977): 7–43.

83 Cf. note 24.

84 Steele 2003: 243.

85 Dietrich Ehlers in Fritz Jürss (ed.), *Geschichte des wissenschaftlichen Denkens im Altertum* (Berlin: Akademie Verlag, 1982), 418.

86 Francesca Rochberg, "A Consideration of Babylonian Astronomy within the Historio-graphy of Science," *Studies in History and Philosophy of Science* 33 (2002): 661–684.

87 Renn 2012; D. A. Warburton, review of *The Globalization of Knowledge in History*, edited by J. Renn, *Journal of Global History* 10 (2015): 198–200.

88 Schiefsky in Renn 2012, 191, 200.

89 Schiefsky in Renn 2012, 192.

90 Renn 2012, 214.

91 Renn 2012, 214.

92 E.g., Harvey Goldman, "Traditional Forms of Wisdom and Politics in Plato's 'Apology,'" *Classical Quarterly* New Series 59 (2009): 444–467; Charles H. Kahn, "On Early Greek Astronomy," *Journal of Hellenic Studies* 90 (1970): 99–116

93 Martin Bernal, "Animadversions on the Origins of Western Science," *Isis* 83 (1992): 596–607.

94 One important problem here is our difficulties in establishing the dates of the astronomical events and thus the potential reliability of any predictions, (e.g., Matthew Robinson, "*Ardua et Astra*: On the Calculation of the Dates of the Rising and Setting of Stars," *Classical Philology* 104 [2009]: 354–375.), let alone confirming observations of events about which certainty is possible.

95 Soderman/NLSI Staff, "The Oldest Lunar Calendars," *Solar System Exploration Research Virtual Institute*, http://sservi.nasa.gov/articles/oldest-lunar- calendars/ (accessed 4 April 2016).

96 E.g., Asger Aaboe, "On the Babylonian Origin of Some Hipparchian Parameters," *Centaurus* 4 (1955): 122–125; Lis Brack-Bernsen and John M. Steele, "Eclipse Prediction and the Length of the Saros in Babylonian Astronomy," *Centaurus* 47 (2005): 181–206.

97 Francesca Rochberg, *In the Path of the Moon* (Leiden: Brill, 2010), 9.

98 Of course this is rather speculative and I do not view it as "proof" or "evidence." I do merely point out that filling lacunae and correcting scribal mistakes is done rather freely by philologists struggling with ancient texts, and thus the practice of "fiddling" in this fashion hardly unknown.

99 Couprie 2004: 337 and 336.

100 Joseph A. Schumpeter, *Theorie der wirtschaftlichen Entwicklung* (Berlin: Dunker and Humblot, 1964).

101 Karl Menger, *Grundsätze der Volkwirthschaftstheorie* (Vienna: Wilhelm Braumüller, 1871).

102 Alan Ebenstein, *Friedrich Hayek* (New York: Palgrave, 2001), 27.

103 Rudiger Dornbusch, Stanley Fischer, and Richard Startz, *Macroeconomics* (Boston: Irwin McGraw-Hill, 1998)

104 Neugebauer 1954.

105 Helmut Schneider in Walter Scheidel, Ian Morris, and Richard Saller (eds.), *The Cambridge Economic History of the Greco-Roman World* (Cambridge: Cambridge University Press, 2007), 144–171.

106 Schneider in Scheidel et al. 2007, 170–171.

107 Schneider in Scheidel et al. 2007, 167.

108 K. Alishan Yener, *The Domestication of Metals* (Leiden: Brill, 2000).

109 Susan Pollock, *Ancient Mesopotamia* (Cambridge: Cambridge University Press, 1999).

110 For discussions of economic history and theory as well as technology and ancient economics, cf. David A. Warburton, *Macroeconomics from the Beginning* (Neuchâtel: Recherches et Publications, 2003); David A. Warburton, *The Fundamentals of Economics* (Neuchâtel: Recherches et Publications, 2016).

111 I would respond to anyone taking issue with this statement by quoting Mani Matter (concerning his "Ballade vom Nationalrat Hugo Sanders"): "*Jedi ähnlichkeit mit läbende persone hei sech die sälber zue z'schrybe.*"

112 Cf., e.g., David A. Warburton, *Architecture, Power, and Religion* (Berlin: Lit, 2012)

113 Anthony Spalinger, review of *Calendars and Years: Astronomy and Time in the Ancient Near East*, edited by John M. Steele, *Journal of the American Oriental Society* 131 (2011): 311–313.