Ancient Skies: Early Babylonian astronomy, with specific reference to MUL.APIN

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Abstract - English

This thesis is an attempt to investigate whether the Babylonians of the periods prior to the 6th Century BCE possessed an interest in the workings of celestial bodies reaching beyond the scope of what would today be regarded as *astrology* – the idea that the movements of the stars were signs from the gods, foretelling the future. The objective is thus to see whether it is possible that at least some of the texts recording the phenomena present in the night sky could have been compiled for what could be termed a more “scientific” purpose: recording the stars out of an interest in how the universe works.

It will be acknowledged that to the people of the time, the formal study of the movements of astral bodies, as well as any supernatural implications they might hold, were not separate fields. This, of course, stands in contrast to the differentiated modern schools of *astronomy* and *astrology*. In order to investigate the possibility that to some individuals the former took precedence (and by implication that they possessed what could be termed a more “scientific” frame of mind), selected sources, particularly the different sections of the text known as *MUL.APIN*, will be analysed for signs of content and approaches more befitting to the field of generalised study than that of divination.

It will be found, however, that although some texts do show signs of study isolated from divination (through, for example, the inclusion of detail which would have no relevance to the aforementioned), others, which at first glance appear purely astronomical, contain information contrary to what would be expected of a thorough investigation of visible reality. This includes idealised dates and intentionally falsified information, inserted to have the recorded universe appear to conform to conservative ideology. In order to make this point clearer, cosmological aspects of this ideology will be introduced even before the astronomical texts are analysed.

Finally, it will be concluded that while scientific inclinations amongst the individuals recording the stars during this era was by no means the norm, there are indications that they were emerging in some. Though the field of Babylonian astral observations during this period cannot, as a whole, be classified as a science, does not mean that all its practitioners should be disqualified as scientific thinkers.

Opsomming – Afrikaans

Hierdie tesis is ’n poging om te ondersoek of die Babiloniërs van die periode voor die 6de eeu v.C. ’n belangstelling in die werking van die hemelliggame gehad het anders as wat vandag as *astrologie* beskou sou word – die idee dat die bewegings van die sterre tekens van die gode was wat die toekoms voorspel. Die doel is om te kyk of dit moontlik is dat ten minste sommige van die tekste wat die verskynsels van die naghemel aanteken vir ’n meer “wetenskaplike” doeleinde geskryf is: die dokumenteer van die sterre uit ’n belangstelling in hoe die heelal werk.

Daar word erken dat vir die mense van destyds die formele studie van die bewegings van hemelliggame, asook enige bonatuurlike implikasies wat hulle mag inhou, nie afsonderlike velde was nie. Dit is in teenstelling met die onderskeie moderne skole van *astronomie* en *astrologie*. Ten einde die moontlikheid te ondersoek dat vir sommige individue eersgenoemde voorrang geniet het (en by implikasie dat hulle ’n meer “wetenskaplike” denkwyse besit het), word geselekteerde bronne, veral die verskillende afdelings van die teks bekend as *MUL.APIN*, geanaliseer vir aanduidings van inhoud en benaderings wat meer van toepassing op die wetenskaplike veld as dié van divinasie is.

Daar is egter bevind dat alhoewel sommige tekste aanduidings toon van studie wat onderskeibaar is van divinasie (byvoorbeeld, deur die insluiting van besonderhede wat van geen toepassing op die voorgemelde is nie), bevat ander, wat aanvanklik suiwer astronomies voorkom, inligting in teenstelling met wat van ’n deeglike ondersoek van die sigbare werklikheid verwag sou word. Dit sluit geïdealiseerde datums en opsetlik vervalste inligting in wat ingevoeg is om die aangetekende heelal skynbaar aan konserwatiewe ideologie te laat voldoen. Om hierdie punt duideliker te maak, word die kosmologiese aspekte van hierdie ideologie bekendgestel voor die astronomiese tekste geanaliseer word.

Ten slotte, word die gevolgtrekking gemaak dat ofskoon wetenskaplike neigings onder individue wat die sterre gedurende hierdie tydperk gedokumenteer het geensins die norm was nie, daar wel aanduidings is dat dit in sommige te voorskyn kom. Hoewel die veld van Babiloniese sterrewaarneming gedurende hierdie periode nie in sy geheel as ’n wetenskap geklassifiseer kan word nie, beteken dit nie dat al sy beoefenaars as wetenskaplike denkers gediskwalifiseer moet word nie.

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1. INTRODUCTION

The night sky is beautiful to look at. Stars shining in the dark fascinate modern viewers of the sky as much as they did people living thousands of years ago. For those captivated enough to view the sky over long periods and across successive days, it becomes obvious that the sky is not a stagnant beauty – everything in the sky tends to move. Once the interest of the viewer has been peaked and attempts are made to identify exactly how these objects move, astronomy is born.

Astronomy can be defined as “the disinterested scientific study of celestial phenomena” (Black & Green 1992: 36). It is the science which deals with space, celestial objects and the physical universe in its entirety (Concise Oxford Dictionary). It is derived from Greek, “astro-nomos,” which means “star arranging.”

One ancient civilization which developed an early interest in the movements of the stars was the Babylonians. Texts which deal with celestial phenomena are already quite large in number by the beginning of the first millennium BCE, and these are by no means even the oldest texts dealing with the subject. The Babylonians, as such, can be said to be early examples of astronomers - investigators of the stars - and by implication scientists.

According to the Concise Oxford Dictionary, science is defined as:
The intellectual and practical activity encompassing the systematic study of the structure and behaviour of the physical and natural world through observation and experiment;) the systematically organised body of knowledge on any subject.

Science thus strives to find the nature of a given subject, without making assumptions or drawing conclusions outside the observable evidence. How this knowledge is applied does not matter; in Babylonian terms, as shall be discussed, it is therefore perfectly acceptable that it be used to tell the time. However, once immeasurable and unobservable factors are added, the system is no longer a science, but a belief. In terms of the movements of celestial bodies, it is therefore important to divide astronomy from a very similar term, astrology.

Astrology, in contrast to astronomy, is defined as “the observation of the movements of the stars with respect to the divination of the future” (Black & Green 1992: 36). Although the subject matter appears to be similar to astronomy at first glance, the associations of the movements of the stars with the indefinite, unobservable and incalculable factor of future events disqualifies it as a science, and thus separates it from astronomy itself.

While the Babylonians are seen to have an apparent interest in astronomy, their belief in astrology is without question. Very early in their history, texts appear which connect the movements and appearances of the Sun, Moon and stars with predicted future events. Unfortunately, the Babylonians did not distinguish between astronomy and astrology (Koch-Westenholz 1995: 21), their similar subject grouping them together into a single corpus, and thus it is often difficult to determine where the science ends and the belief starts, if the science is present at all. This is particularly true for the earliest celestial observations.

This interlinked nature of the two different modern terms often undermines the view of the Babylonians as people with a scientific frame of mind. The modern assumption, after all, is not simply that astrology does not belong to the field of science, but that it goes against it completely. As such, the position of Babylonians as scientists is questioned.

The investigation that follows is an attempt to define that the Babylonians were not devoid of a scientific frame of mind with respect to the early observations of celestial bodies.

2. DESIGN AND SOURCES

In order to prove a scientific mindset in the Babylonian approach to stellar investigation, texts of suspected astronomical content need to be identified and analysed for clues hinting towards this condition. Special attention obviously needs to be paid to texts which were well known during antiquity, to see how far this principle applies.

In order to identify such texts, a brief knowledge of the history of Babylonian astronomy is first required.

The earliest texts indicating Babylonian interest in celestial bodies dates to approximately 1700 BCE (Bienkowski & Millard 2000: 40). The interest during this time, however, seems to be purely astrological; the texts all being what are known as "omen" texts. A standard series of these omen texts was finalised in approximately 1000 BCE, and was named *Enuma Anu Enlil*. By this time, however, the first astronomical texts, known as astrolabes, had already appeared – texts which made use of astronomical observations to serve calendar functions. During the Neo-Assyrian period (9th-7th centuries BCE), individual scholars were tasked to observing the heavens in order to make predictions of the future for the king (Bienkowski & Millard 2000: 40). Many such letters of correspondence still survive. The astronomical knowledge of this and earlier periods was then accumulated into a compilation text known as MUL.APIN, this being in approximately the seventh century BCE, and marks the end of the "early" period.

The "later" period began in approximately the 6th Century BCE, and saw the rise of texts known as "astronomical diaries." These recorded the positions of the stars each night with incredible precision, as well as recording important political and economic events (Bienkowski & Millard 2000: 40), possibly in order to draw up future omens. From this period time onward, astronomy itself became more and more accurate, with the periods of stellar phenomenon (including those of eclipses) calculated by means of complex ephemeris tables (Olmstead 1938: 20). The transition of merely observing to mathematically predicting astronomical phenomena has led to the astronomy of the time as being classified separately as "mathematical astronomy." The last dated text of this period is dated 75 CE (Rochberg-Halton 1995:1932).

For the purpose of determining whether the Babylonians subscribed to a scientific frame of mind during the earlier, non-mathematical period, the following texts have been identified for investigation:

Enuma Anu Enlil (Section 4.1)

The first major text, *Enuma Anu Enlil*, is as has been stated, an astrological rather than an astronomical text. In terms of popularity, however, it is the most widely known of the stellar texts; so prominent, in fact, that it lent its name to the scribes of the entire combined corpus. Despite being mostly of an astrological nature, there are hints in one section of proper scientific approach – the oldest known. *Enuma Anu Enlil* thus needs to be included in the investigation.

Astrolabes (Section 4.2)

The second text, the astrolabes, is the first example of a text which can be declared as truly astronomical. The system it set in place was also followed by many of the astronomical texts to follow, and so is an obvious inclusion.

MUL.APIN (Section 5)

The third text, which is also the primary text, is the largest compendium of astronomical texts known from the "early" period of Babylonian astronomy, MUL.APIN. The text will be divided into multiple sections, each suspected to originate from a different source, and analysed in terms of its astronomical content. This will serve to indicate exactly what the Babylonians knew and how thorough they were in their investigations, as well as hinting at exactly how scientifically minded they were.

AO 6478 (Section 6)

The final text to be discussed will be the unnamed tablet AO 6478, chosen due to its relation to MUL.APIN, as an indicator of the progression of the systems used.

Texts of the later (mathematical) Babylonian astronomical corpus, such as the Ephemerides, will not be covered. Though the accuracy of their data is extremely impressive and their categorization as astronomical texts without question, it is more important to investigate the appearances of the scientific mindset during the earlier periods. While the ephemerides are known to be the "peak" of Babylonian astronomical knowledge, the evidence of the existence and progression of the scientific mind can be concluded without delving into these extremely mathematical texts.

Before examining the identified texts, however, it is prudent to in fact first delve into the unscientific side of astronomical knowledge. Since astronomy is the study of the stars, it is important to define exactly what it is the Babylonians believed it was that they were studying. The only sources for this information, unfortunately, come from myth. While myth is generally regarded as “unscientific” itself, the fact of the matter was that the scribes making the calculations of the astronomical tablets most likely believed, or were aware of, these myths. MUL.APIN, despite being considered “astronomical,” still indicates religious and mythological connections to its data. Belief in myth does not stop one from still following scientific approaches, rather, though it may in fact change the way data is approached.

As such, the cosmogony of the stars with respect to popular belief needs to be investigated first, and perhaps the implications of these cosmological aspects with respect to later astronomical systems introduced.

Enuma Elish (Section 3.1)

The first text to be investigated with respect to stellar cosmology is the Babylonian Epic of Creation, *Enuma Elish*. It is chosen for the fact that it was the most well known cosmological text in circulation during the period the others texts to be investigated were written. Not only does it indicate how the stars came to be about, it is also the origin of much of the religious connotations stars held even in astronomical texts like MUL.APIN. The mention in the text of the system of astrolabes, one of the astronomical texts to be examined, helps to define that text’s prominence in society. The discussion of Enuma Elish will be followed by a short description of other creation epics for purposes of comparison.

KAR 307 & AO 8196 (Section 3.2)

The next set of texts, a pair of unnamed tablets designated KAR 307 and AO 8196, are chosen as the only really valid sources of information for the belief of where the stars could be found – what space entailed. While their dating should actually exclude them from the period of investigation, their content is at least suspected to be older than the texts themselves, and no other sources for this information are available.

The Etana Epic (Section 3.3)
The last cosmological text, Etana and the Eagle, is chosen to help better define the information presented by the previous texts, KAR 307 and AO 8196, by giving a finite value for one of the levels of Heaven, and thus limiting the actual height of the stars in the sky. While this information does not seem very exact, it helps to provide a stark contrast with values determined in the astronomical text AO 6478, and thus shows that established institutions were sometimes ignored in favour of more accurate data.

Finally, after the various texts have been investigated, a few points will be made about the astronomical scribes, since it is their mind frame that is being analysed for hints of scientific inclinations. A brief summary of the conclusions drawn from the investigations of the various texts will then end the investigation.

3. COSMOLOGY AND THE STARS

Stars, in their most easily definable form, are points of light. The object (or objects) emitting or reflecting this light is so far away from the observer that all we can see is a tiny speck. Though seemingly obvious, a condition for being termed a “star” is that this point of light must occur in the sky (else this definition could apply to things as mundane and inappropriate as domestic lighting when viewed from a distance). In true astronomical terms, however, a star is a giant ball of gas, constantly undergoing nuclear processes, and as such constantly emitting electromagnetic waves. The light waves produced from these reactions are particularly intense, such that the object can be seen from extremely far away. Our Sun is, of course, such a star, albeit a rather small and lonely one (most stars are many times larger and are often paired with a sibling star). For ease of use, however, the term “star” is mostly used to describe all the similar lights in the night sky, be they planets or entire galaxies in reality. Ironically, star is usually not applied to the Sun.

In Babylonian culture, “star” has even broader connotations than the loose modern usage of the word. The word for “star” is MUL in Sumerian (Horowitz 1998: 153) or *kakkabu* in Akkadian (Civil et al. 1971: 45). MUL, however, can mean a fixed star, a planet, a comet or an entire constellation. As such, when the term “star” is read in the following sections, it should not be assumed to necessarily indicate a single star (in most cases, in fact, it will refer to a constellation).

Since the modern understanding of stars has been acquired through the use of complex instrumentation, it is understandable that the conceptualizations of the nature of the stars in ancient Mesopotamia are by no means scientific. It is likely that even the more scientifically-minded scribes would have based their assumptions of the nature of the stars on fixed traditions. Since these assumptions would be likely, then, to influence their compositions of later more scientific texts, it is necessary to investigate what their likely understanding of the nature of the stars could have been, and thus the traditions which would be suspected to lead to these views need to be investigated. As such, it is the well-known stories and myths of the period in question which need to be taken into consideration.

3.1 COSMOGONIES

When investigating the nature of the stars in the cosmological-religious sense, the best place to start is the place where everything starts – to clarify, with stories of how the universe began. Stars, as a prominent part of the universe, are likely to have their origins explained in such tales. The first text to be discussed is, as such, the Babylonian Epic of Creation, *Enuma Elish*.

3.1.1 ENUMA ELISH

Although the earliest exemplars of *Enuma Elish* available to us date back no further than the early first millennium (Horowitz 1998: 108), it is believed to be somewhat older. More likely than not, the story itself was probably conceived of as far back as the Old Babylonian period, when the city of Babylon rose to the most prominent position amongst the Mesopotamian cities under Hammurabi and his successors. *Enuma Elish*, after all, introduces the Babylonian city god, Marduk, as the most important of the gods, and installs him as the creator of the universe (Ee IV: 138-146). Even if the myth was not conceived of during this period, according to Horowitz (1998: 108) it was likely already established by the Kassite period. As he points out, an inscription of the Kassite king Agum I (thus from approximately 1570 BCE) describes how the cella of Marduk (and Sarpanitum) has its doors decorated with creatures which have their origins in this creation myth.

As a text (or at least a story) which could have been responsible for an individual's view of the world, and perhaps the stars, it is a likely candidate. *Enuma Elish* was well known, being recited every year on the fourth day of the New Year Festival (Oates 1979: 169), and so the view it presents would most likely be accepted as truth in the absence of better alternatives.

As with other cuneiform texts, *Enuma Elish* is named after the first words which appear on the tablet: *enuma eliš la nabû šámamu*. Together with many other important texts in this field, it was first translated by King (1902), who translates this first line as "When in the height heaven was not yet named." The epic spans seven tablets, of which we have many different exemplars. As such, much of the text missing from King's initial translation has been filled in.

The translation used for purposes of this investigation is taken from:
Forster, B.R. 2003. "Epic of Creation (Enuma Elish)," in Hallo, W.W. (ed.) *The Context of Scripture, Vol. I: Canonical Compositions from the Biblical World*. Leiden: Brill.
All quotations from the translation itself are given in the format Enuma Elish [Tablet number]:line numbers. Note that the spellings of names are not necessarily identical – Forster avoids signs such as Š.

According to this creation story, in the beginning, there was water… or more specifically, the deities Tiamat and Apsu (Ee I: 3-5), the personifications of what would later be the sea and underground water (Horowitz 1998: 109). They mixed their waters together, and several gods were born: Lahmu, Lahamu, Anšar, Kišar (Ee I: 10-12). Anšar was the father of Anu, who was the father of Nudimmud (more commonly known as "Ea", also "Enki"– the names are used interchangeably even within *Enuma Elish*). As such, the universe began not with the creation of a space, but directly with the birth of deities originating from the water. This is an interesting theory, very unlike the majority of creation stories throughout history, and has an interesting modern link – most scholars today believe that all life on our planet indeed originated from the water.

The space in which these gods dwelled, Anduranna (Horowitz 1998: 109), was inside of Tiamat (the female of the original pair – of the "matrix) (Ea I: 4), and the activities of the gods inside her were such a hindrance that she could not rest or sleep (Ee I: 38). Together with Apsu and Mummu (said to be the pair's advisor, though his origins are unclear) they plotted against the gods, but this plan was halted by Ea. He cast a spell on Apsu, putting him to sleep (Ee I: 64-65), and stole his powers (aura) for himself (Ea I: 68). The defeated Apsu is then forever turned into an ocean (Horowitz 1998: 111) on which Ea erects his own home after also defeating the advisor Mummu (Ee I: 70-71).

The fall of her partner enrages Tiamat, who then declares open warfare on her godly children. By the end of the first tablet, she has created 11 new species of monster for the sole purpose of warfare (amongst these are the creatures previously stated as appearing on Marduk's cella), and chosen the god Kingu as her new companion, granting him power and giving him the "Tablet of Destinies" (Ea I: 156). Tiamat is not as easy an opponent as Apsu was: events can be summarised by Anšar's own words (Ee III: 55-56): "I sent Anu, but he could not withstand her; Nudimmud was afraid and turned back." Eventually, the task fell upon the god Marduk (often referred to as "Bel"), who accepted the task with one condition: he would need to be made king of the gods (Ee III: 159). The gods agree, but decide to test his power, and now an event of considerable interest to those seeking an understanding of Babylonian cosmology with respects to the night sky occurs.

The gods create something which they tell Marduk to make disappear and reappear through the power of his word alone. This word was originally translated by King as "garment" (Ee IV: 19), but is now read as "constellation". This first constellation (*lamā šu*) is then made to disappear and reappear at Marduk's command (Horowitz 1998: 111). Horowitz's assumption that this is a forerunner of things to come is probably correct – later constellations, after all, disappear over the horizon only to reappear again on the opposite side a few months later. The investigation of *Enuma Elish* cannot stop here quite yet, however, since at this point in the epic, even though the first constellation has appeared, it is all alone and does not even have a place in the sky to sit.

The epic naturally progresses into a fight between Marduk and Tiamat, where Marduk defeats Tiamat by forcing her mouth open with wind (Ee IV: 98) and then driving his spear through her mouth into her heart. Kingu is also defeated (having being so terrified of Marduk that he could not accomplish much) and the monsters subjugated. Marduk then takes the body of Tiamat, and uses it as building material to create the rest of the known universe, the surface of the Earth (*Ešarra*) and the heavens (*Ašrata / šamāmū*), each of them the same size as the already existent Apsu (Horowitz 1998: 112-113). He assigns each of these regions to a different god: Anu receives the Heavens, Enlil the Earth and to Ea, he leaves the Apsu (which Ea himself had built and claimed in any event). A note of interest: with respect to *Ašrata* (the heavens), when Marduk speaks of it to the other gods later, is said to have a solid floor ("whose ground I made firm" - Ee V: 121). This will be discussed in more detail in Section 3.2: The Three Levels of Heaven.

Marduk's shaping of the world eventually reaches the stage of most importance to those interested in understanding Babylonian conceptualization of the night sky at the beginning of Tablet V:

"He made the positions (stations) for the great gods. He established in constellations the stars, their likenesses" (Forster 2003: 399 - Ee V: 1-2).
As such, according to *Enuma Elish*, the stars in heaven are all the creations of Marduk, and, just as importantly, the stars are likenesses (we can go so far as to say representations) of the gods themselves.

"He marked the year, described its boundaries. He set up twelve months of three stars each" (Forster 2003: 399 - Ee V: 3-4).
These lines link directly with texts discussed later, the "Astrolabes" – they imply that each month could be identified by a succession of three stars/constellations rising in the sky within three separate bands, which will be discussed in more detail in Section 4.2: The Astrolabes.

“After he had patterned the days of the year, he fixed the position of Neberu to mark the stars’ relationships. Lest any make an error or go astray, he established the positions of Enlil and Ea in relation to it” (Forster 2003: 399 - Ee V: 5-6).
Neberu is the only star in *Enuma Elish* to be mentioned by name, and is also, according to Tablet VII line 136, one of the names of Marduk himself. As such, Neberu is Marduk’s star, and so it should be obvious that it has prominence. This star is said to set the course for the rest, shepherding the stars like sheep (Ee VII: 130-131), but considering that there are three bands in the system mentioned, it required two other stars to accompany it; these being the stations of Enlil and Ea.

After the creation of the stars, Marduk opens “gates” on the “two sides” (Ee V: 9) – this is a vague reference to gates which the Sun, Moon and possibly stars travelled through as they appeared or disappeared over the horizon, the two sides obviously implying East and West. The Gates of Heaven are mentioned often outside of this text, particularly in prayers to Šamaš/Utu, such as the Prayer to the Gods of the Night (Heimpel 1986:130). It should be noted, of course, that the Sun has not yet been placed in the sky at this point in *Enuma Elish.*

After the stars are created, Marduk installs the Moon into the region known as *elatu* (The Heights) (Horowitz 1998: 116). Sadly, *Enuma Elish* disappoints those hoping for a glimpse of early astronomical insight on the part of the Babylonians by saying that the Moon waxes and wanes simply because Marduk commanded it to do so (Ee V: 15-22). The fact, however, that Marduk commands that the Moon should wax for the first 15 days of the month and then wane for the rest gives us a piece of seemingly obvious but nevertheless valuable information: the length of a month was regulated via the phases of the Moon. This is, of course, exactly the opposite of what is said, but logical thought (as well as the simple fact that the system on months was in place before the writing of this myth) dictates that this must be the case.

The information relevant to the study of the stars unfortunately ends at this point for *Enuma Elish*, since lines 23-46 of Tablet V are incomplete in all known exemplars (Horowitz 1998:117). The few fragments which are available indicate that they spoke about the Sun, the year and the divisions of daylight and night-time (watches), which would have been interesting to connect with the later texts to be studied. Sadly, when the text picks up again at line 47, the focus has shifted from the astral bodies to rain.

Only after the stars and the heavenly bodies have been created does Marduk create the features of the Earth’s surface, despite the fact the Ešarra had already been conceived. Interestingly, according to another creation epic, *The Bilingual Creation of the world by Marduk* (CT 13), Marduk creates the Earth’s physical surface by heaping dirt on a raft (Horowitz 1998: 118). Amazingly, only after the stars and the surface have all been created does Marduk separate the regions of Heaven and Earth, by setting up Tiamat’s crotch as a brace (Ee V: 61).

The epic continues with the creation of the city of Babylon and the installation of the gods into heaven and the underworld. As written, the epic seems to indicate that 300 Anunnakkū were installed in heaven and 300 in the underworld (Ea VI: 40-44), while 300 Igigi were assigned to heaven and 600 to the Netherworld (Ea VI: 69). This is possibly a mixture of traditions – later texts usually term the heavenly gods Igigi and underworld gods Anunnakkū (Black & Green 1992: 34). The epic ends with an exaltation to Marduk. Forster is of the opinion that this is the focus of the entire myth, and as such the epic could just as easily be called “The Exaltation of Marduk” (Forster 2003: 391). In terms of our understanding of Babylonian cosmology with respect to the stars, as well as any hints to astronomical knowledge, the final two tablets speak of very little apart from the aforementioned explanation of Neberu, but there is, however, one other important exception: after everything else has been created and the universe is in order, Marduk installs a final constellation, the Bow, in the heavens (Ee VI: 90-91) – the constellation of the goddess Ištar (Horowitz 1998: 24).

To summarize the important data obtained from *Enuma Elish*:

Against all odds, there is not only mention of stellar cosmology, but also a reference to an actual astronomical text within this epic. The mention of the astrolabes in the “official” story of creation implies that this text was accepted and used on a wide scale. It can be described, in brief, as a system in place to determine, via the stars, what month of the year it was, and that Marduk’s star (Neberu) played an important role in this system. It can also be concluded that a principal time unit in use by all societies (the month) was determined by astral phenomenon, the phases of the Moon. Needless to say, however, that *Enuma Elish* is by no means an astronomical text, but at least helps us better define the concept of what the people believed about stars in the cosmological sense of the word.

In terms of astral cosmology: The first constellation was created by the various gods to test Marduk, but the rest were created by Marduk himself. One constellation, the Bow, was installed only after the rest of the universe was completed. The stars were set up in the Heavens, which were created out of the body of Tiamat (implying that they were created from water). The stars passed through the horizons via "gates." The Moon came into existence after the stars, and changed its form due to divine command. Finally, the stars themselves were likenesses and representations of the various gods. Quite often in astronomical texts, when referring to a star, the text will refer to it as "the god."

Unfortunately, *Enuma Elish* does not show any signs of a logical or scientific mind behind any of the events that take place or the aspects of the universe that are created, except perhaps for the already mentioned fact that the gods originated from water (truly the source of life). More substantial evidence of the existence of Babylonian scientific minds will have to be searched for elsewhere.

3.1.2 OTHER CREATION MYTHS

[Special mention must be made at this point to the work of Wayne Horowitz, *Mesopotamian Cosmic Geography,* which simplified the task of investigating this aspect of Babylonian cosmology. It is the foremost work on the subject, without which this section would have required an intensive investigation all of its own.]

As has been stated, *Enuma Elish* is used as the basis of investigation for Babylonian cosmological thought with respect to the creation of the stars because it was the "official" account of creation, even though this implies a forced belief or one created from propaganda. But, as has been mentioned, it is the account which would have been most popular during the period we are interested in (the early first millennium

BCE). Particularly when speaking about broader Mesopotamia (rather than just Babylonia) there are several different accounts of creation in existence, which one would suspect to give different ideas about the heaven of the stars. Oddly enough, this is not really the case – the stars themselves are usually just joined to the concept of "heaven", and given little prominence of their own.

Importantly, of course, is that the creator god (when applicable) of most of the accounts is different – only two other accounts of creation by Marduk are known, the first being the aforementioned *Bilingual Creation of the World by Marduk*, known from one relatively complete exemplar (CT 13) (Horowitz 1998: 129) and another partial fragment. The second, *The Babyloniaca of Berossus* (see Burstein 1978), was written after the period of relevance, and originated not from Babylonia but from Greece (Horowitz 1998: 133) (albeit by a priest of Bel/Marduk), so does not apply.

For the most part, if a specific creator god is named, it is usually one of either Ea/Enki, Anu or Enlil. To name some examples: it is in fact suspected that the *Bilingual Creation of the World by Marduk* was originally an Enki myth, as is supported by the occurrence of the name on the smaller fragment text (Horowitz 1998: 130). Tablet NBC 11108, an UR III Sumerian tablet, attests that the first god to exist (along with Ki, "the Earth") and to "make the heavens shine," (Horowitz 1998: 138) (possibly referring to the placement of stars) was Anu in his role as Heaven itself (Rochberg 2005: 317); the same is true for the self-speaking ritual incantation *When Anu Built the Heavens* (Horowitz 1998: 149). In the theology of the religious capital of Nippur, the original creator god was Enlil (Rochberg 2005: 318).

Even when a specific creator god is not mentioned, the division of Heaven and Earth is a popular, recurring theme, and the division of the three gods Ea, Anu and Enlil amongst these regions remains the same, whether by claim or lot, such as in the Akkadian *Atrahasis* (Horowitz 1998: 145).

Unfortunately, the most promising of all the variant creation stories, that which appears in the Akkadian text designated K.7067 (Horowitz 1998: 147), is mostly lost. Only 13 poorly-preserved lines remain. It appears that the text indicated that the stars were created by the "Great Gods." Since the line before this term introduces Ea, we can only assume that the Great Gods must mean the three prominent deities Ea, Anu and Enlil. While they are setting up the heavens, they “multiply the width by the height” (line 6) – implying that everything is precisely calculated. Multiplying width by height gives one the area of a rectangle, the use of which we cannot possibly guess within the broken context, but the link to mathematical calculation has been made. We read that the gods divide up the stations (hinting to the Astrolabe texts), and there is mention of *minas*, the measurement used by water clocks, which shall be discussed at length in Section 4.2: Astrolabes. The text also makes the link between the stars and another aspect of the culture: omens and oracular decisions.

3.2 THE THREE LEVELS OF HEAVEN

The creation myths are the only available hints as to the beliefs of the origins of the stars, but to hope for a more scientific theory of their origin is certainly out of the question. None of the creation myths, however, hint as to exactly what the stars are. It is claimed they are stations of the gods and their representations, but the real physical nature of stars is never explained; nor is their place in the sky detailed.

Two tablets, unfortunately both from a much later period than the rest of the texts to be investigated, help to clarify a few points concerning Babylonian beliefs about the stars with respect to the latter – their place in the sky. While the tablets themselves are from a later period than the rest of the text, it is suspected, however, that the views they describe are much older, and should thus not be dismissed when attempting to create a cosmic picture for the earlier periods.

The tablets in question are designated by the museum numbers KAR 307 and AO 8196 (Horowitz 1998: 3). The sections of interest reads as follows, taken from Horowitz (1998) and checked against Huxley (1997) for KAR 307.

KAR 307

30. The Upper Heavens are *luludānītu*-stone. They belong to Anu. He settled the 300 Igigi inside.

31. The Middle Heavens are *saggilmud*-stone. They belong to the Igigi. Bel sat on the high dais inside,
32. in the lapis lazuli sanctuary. He made a lamp of electrum shine inside.
33. The Lower Heavens are jasper. They belong to the stars. He drew the constellations of the gods on them.

AO 8196

20. The Upper Heavens are *luludānītu*-stone. They belong to Anu.
21. The Middle Heavens are *saggilmud*-stone. They belong to the Igigi.
22. The Lower Heavens are jasper. They belong to the stars.

The two texts are remarkably similar – so much so that it is expected that they were derived from the same source (Horowitz 1998: 8). KAR 307 adds extra information to the end of each line, most likely derived from a second source. This combination of data leads to a slight discrepancy, in that the Igigi gods are placed in both the Upper Heavens and Middle Heavens (Horowitz 1998: 8), though that is not to say that they did not occupy both. The placing of the Igigi in the heavens in general is known from *Enuma Elish* (Ea VI: 69), and in line 37 of KAR 307, it is noted that 600 Anunnaki dwell in the underworld. This is the later division of the gods known from the Kassite period (approximately from the 15th to the 12th centuries BCE) (Horowitz 1998: 8), and so this should be considered the earliest possible origin for the worldview described within.

The text implies that the heavens are split into three different sections, Upper, Middle and Lower, and each is said to be made out of a different stone - this warrants some investigation before any astronomical assumptions can be made. The first, and most logical assumption that can be made, is that the heavens are not, as in many other cultures, a completely spiritual realm floating in the sky. They have a very physical component: they are made out of stone. Of course, the gods live in the heavens, there are shrines and sanctuaries – so the stones the heavens are made out of are probably a description of their floors. Huxley (1997: 190) believes the opposite; that the stones listed are for the roofs.

Of the three heavens, the highest level of the heavens, or Upper Heavens, is the first to be mentioned. When Marduk is said to assign the heavens to Anu, this is apparently the level he is given, or is at least the level in which he can be found. The Upper Heavens are said to be made of *luludānītu* stone – a stone of which the modern equivalent is unclear. Fortunately, the Babylonians themselves compiled a text called *Abnu-šikinšu,* written for the very purpose of identifying different stones.
Abnu-šikinšu (STT 108) line 15 states:

"The stone whose appearance is red covered with white and black patches in named of *luludānītu* stone" (Horowitz 1998: 10).

The Upper Heavens, as such, are said to be made out of a majoritively red stone. As far as cosmology of the stars is concerned, however, this fact is of little importance; the compositions of the two lower levels are of greater interest.
The Middle Heavens are where Marduk's own cella can be found, the doors of which, as has been stated, were believed to be decorated with depictions of the monsters of Tiamat. The floor of the Middle Heavens is said to be made out of *saggilmud*-stone. For this stone, *Abnu-šikinšu* (STT 108) line 88 states:

"The stone whose appearance is like lapis-lazuli is named *saggilmud*-stone" (Horowitz 1998: 11).

Lapis-lazuli, of course, is a blue stone. Interesting to note is that Marduk's (Bel's) cella is said to be made of lapis-lazuli itself (according to KAR 307 line 32), creating a picture of a very blue level of heaven. While important in the greater scheme of the universe, this is still not the level of heaven of most interest to astronomical investigation – that role belongs to the heavens one level down.

The level of the heavens closest to the surface of the Earth is naturally the Lower Heavens. They are said to be made out of jasper, though this needs to be clarified. The ancient term for "jasper" referred not only to the stone known as jasper today, but almost all stones from its greater mineral family, chalcedony (Horowitz 1998: 13). Most varieties of chalcedony are translucent – you can see through them. As such, it is possible to look through the floor of the Lower Heavens and see the bottom of the blue-coloured floor of the Middle Heavens – explaining why the sky appears to be blue.

Jasper itself is not colourless, though, so an explanation is required to explain why the shade of the sky was unaffected. Again, the best source for such information is *Abnu-šikinšu*, which, in lines 76-77 of the previously used exemplar (ST 108) state:

“The stone whose appearance is like the clear heavens is named jasper.
The stone whose appearance is like a rain cloud is named jasper.”
(Horowitz 1998: 14)

Jasper, then, is by itself the blue colour of the sky. Even without being translucent, the sky itself would still appear blue. The second line from *Abnu-šikinšu* presents an interesting thought – by relating the cloudy sky to jasper, it makes one wonder if there is perhaps a connection. Other shades of jasper included purple, yellow and red (Horowitz 1998: 14) – the colours of the sky at sunset. This is simply conjecture, however; there is no evidence that the jasper of the Lower Heavens was in any way transformational. No explanations for these changes in the sky are, unfortunately, known.

While the nature and colour of light is of interest to scientific study, what is more important with regards to the Lower Heavens is that they belong to the stars. The first fact to note is that the stars and constellations are said to be drawn – the “paint” used (which would help in identifying exactly what the physical stars were supposed to be) is not mentioned, but the constellations are said to be drawn directly onto the jasper. The term used in the text, *inna muhhi*, is said to imply that this inscription was done on the side of the stone facing the Earth (Horowitz 1998: 14), so one did not look through the translucent stone to see them.

Considering that the stars were seen to move across the sky in a fixed fashion, being drawn on a solid surface seems a logical conclusion. Sadly, there are no satisfactory explanations for this aspect of cosmology known from Babylonian sources, so it can only be assumed that the people believed the skies rotated (Huxley 1997: 192), most probably due to divine command.

In terms of astral cosmology, as such, tablets KAR 307 and AO 8196 thus help define the relative position of the stars in the universe. They appear on a special surface of the heavens, made of jasper, which is somewhat lower than the realms of the gods themselves.

In terms of actual astronomical content, KAR 307 mentions two pieces of information before the section introducing the levels of heaven, which have not yet been introduced. The first is that the disk of the Sun in the heavens is 60 *bēru*, and that of the Moon is 40 *bēru* (Horowitz 1998: 5). It is not stated how these values are obtained, and should not be assumed to belong to a defined corpus. Naturally, these values are nowhere near correct: with reference to the calculations which will be presented in Section 3.3: Etana and the Eagle, the moon is about 17 times larger than the given value (at 3476 km) (Reidy & Wallace 1991: 54), and the Sun is more than 4500 times larger (at about 1 400 000 km) (Harrison 1981: 25).

With regards to indications of increasingly more scientific approaches to recording and explaining the phenomena of the sky, the tablets show varying amounts of promise. KAR 307 is actually a religious compilation detailing mythological events, and as such the completely arbitrary assignment of values for the sizes of the Sun and Moon are not surprising. AO 8196, on the other hand, is in fact an astronomical tablet with similar types of content to MUL.APIN (the primary text to be discussed). Sadly, not much of the tablet remains intact, and in any event the text itself has an origin later than the period of interest – but the scientific approach to the tradition of the heavens, which is believed to be older, can be investigated.

Explaining the composition of the heavens through the use of stones is, to a certain degree, logical. In order to conform to wider religious beliefs, which stated that there were structures in heaven, they would need to have a solid floor. Through association, solid material which thus matched the colour of the heavens is the obvious conclusion. This process of association cannot, however, hold true for the Upper Heavens, since they were not visible from the Earth’s surface. The only explanation for the constitution of the Upper Heavens, it appears, is mythological (thereby virtually arbitrary) assignment originating in older traditions. Even while the listed constitution of the Lower Heavens can be believed to have its origins in deductive logic, this is not the type of logic a scientific mind subscribes to. Deduction from baseless facts is not just unscientific; it goes against the spirit of science completely. No hints of scientific approach can thus be detected within the theory of the heavens.

3.3 ETANA AND THE EAGLE

The highest level of the heavens mentioned in KAR 307 and AO 8196, the Heavens of Anu, are mentioned in several other texts, one of which is the very well known Epic of Etana. Like *Enuma Elish*, it is simply a story, but it deals with a real historical figure and was so well known to the people of ancient Babylon that any apparent cosmological information it included would likely have been incorporated into the understanding of the general populace.

The translation used for the following section is taken from:
Dalley, S. 2003. “Etana” in Hallo, W.W. (ed.) *The Context of Scripture, Vol. I: Canonical Compositions from the Biblical World*. Leiden: Brill: 453 – 457.

The Epic of Etana focuses around the king of Kish, Etana, who is searching for the Plant of Birth so that he may lift his disgrace of not yet having had an heir (Etana II: 137–140). He asks the sun god, Shamash, for assistance, who tells him to seek the help of an eagle lying in a pit.

The eagle itself is by no means ordinary. It is introduced in the beginning of tablet II as the resident of a poplar tree growing in the shade of a throne-dais. The ground underneath the tree is home to a snake. The eagle is said to catch wild boars, donkeys and even bulls to eat – the snake/serpent similarly catches goats and cattle. Clearly these are particularly large animals. The serpent, however, is wary of the eagle, and as such they pledge before Shamash not to “overstep the limits” Shamash has set (Etana II: 16). The eagle, however, does overstep its limits, and eats the serpent’s young. At the advice of Shamash, the serpent then sets a trap for the Eagle, lying in wait inside the carcass of a wild bull (Etana II: 73-88). When the eagle starts to eat the carcass, the serpent cuts its wings and throws it into the pit where Etana finds it.

After Etana nurses the Eagle back to health, the Eagle combs the Earth for signs of the Plant of Birth, but is unsuccessful. Eventually, the eagle suggests to Etana that they fly up to Heaven to speak directly with Ishtar, the goddess of birth. It is implied that Ishtar would have been able to reveal the location of the plant, or possibly assist Etana directly.

The fragmentary nature of the rest of the epic makes it difficult to determine exactly in what order certain events now occur. In Dalley’s translation quoted here, the first attempt at an ascent into the heaven’s fails, as Etana becomes scared, but after both he and his wife receive a dream, Etana and the eagle attempt the flight again.

The second ascent into heaven is what is of considerable interest in terms of understanding the Babylonian view of the universe: the flight is given a distance. As the two are flying up towards heaven, the eagle stops each time after the pair has ascended one *bēru* into the sky, during which time they gaze upon the land, Etana amazed by how small everything becomes. After the third such stop, they eventually reach the Heaven of Anu (Etana III: 38).

As has already been mentioned, Etana was a popular epic. Depictions from the story already appear on cylinder seals from 2300 BCE (Baudot 1982: 1-8, Dalley 1993: 453), and the supposed author of the text, Shulgi’s scribe Lu-Nanna, lived during the late second millennium BCE (Dalley 1993: 453). Considering that the latest tablets used in its translation originate from the Neo-Assyrian period, the epic was certainly widely known. As such, most of the literate populace would have been exposed to the value of 3 *bēru* for the height of the Heaven of Anu.

Dalley (1993: 45) translates the term *bēru* as “mile” in the translation quoted above, but this is not correct. A *bēru* is defined in Babylonian terms as the distance in which a person walks in 2 hours (Van der Waerden 1949: 6). Considering that the average person walks at a rate of between 2.2 and 2.5 kilometres per hour, a *bēru* is roughly equal to five kilometres. As such, the closest modern equivalent unit is the league (3 miles). Using this value, it can be stated that the Babylonians believed the Heaven of Anu to be 15 kilometres up into the sky.

There is no mention of the other levels of heaven in Etana and the eagle; the epic is undoubtedly older than the tradition of multiple Heavens. It is true that Etana and the Eagle do make two stops before reaching the Heaven of Anu, but there is no indication that these occurred due to reaching different layers. However, for those people who used the traditional values of Etana, this meant that the level of the stars would need to be much further down than the 15km mark.

In terms of astronomical value, the Etana epic contains no information. Any hint of a scientific approach to explaining the visible universe is also non-existent; it is a myth in which snakes are capable of eating cows. Unfortunately, due to its popularity, it would nevertheless have influenced the conceptualization of the visible heavens in the minds of later scribes by providing an unusual constraint. Luckily, this view did eventually change, as will be discussed in Section 6: Related Text: AO 6478.

3.4 STELLER COSMOLOGY CONCLUDED

From the above sources, a basic picture of the stars can thus be concluded upon: They were created by the gods and represented the gods; their divine connections, however, are the only hint as to what they really “are”. They were painted onto the surface of the lowest level of Heaven, made of Jasper, which rotated in such a way as to make them appear to move.

While these concepts are important to know before delving into more scientific texts, they are themselves void of any indication of scientific mind frames amongst early Babylonian scribes. Having paved the way, however, it is now possible to begin investigation of the more important works with actual astronomical implications.

4. EARLY ASTRONOMICAL TEXTS

It is impossible to give an exact date for the birth of astronomy in Babylon. While texts themselves can be dated, it is impossible to tell when the first person, looking up at the sky, tried to figure out exactly how it worked. Astronomical texts, on the other hand, can be dated, though whether the oldest of those known today were the first to be written is impossible to know. A large amount of texts (more than 1500) are available for the period after 300 BCE (Rochberg-Halton 1995: 1932), but in order to investigate the emerging scientific mind, it is the earlier texts that are most important. Early astronomy, in this case, really pertains to that which was available up until the composition of the tablets of MUL.APIN around the 7th or 8th century BCE.

Babylonian astronomical texts, whether early or late, focus on the movement of celestial bodies. They realised that this movement had interesting implications, as well as practical applications. Astronomy as a science thus began as soon as it became apparent that recording this movement was a good idea. Amazingly, however, the earliest attestable inclusion of astronomical categorization does not seem to have practical application at all, and even more amazingly, this information is found within a text that is, in fact, astrological.

4.1 ENUMA ANU ENLIL

Enūma Anu Enlil, or "When Anu and Enlil…" was the most important and extensive collection of omens for its time. In its entirety, it comprised of (it is estimated) 70 different tablets and 7000 omens (Neugebauer 1969: 101). Many of these were discovered in the library of Assurbanipal in Nineveh (Aaboe 1974: 278), but only one tablet is of interest to the investigation of astronomy and scientific approaches: tablet number 63 (Reiner & Pingree 1975: 7).

Tablet 63 is also known as *The Venus Tablet of Ammişaduqa*. It is the final tablet in the series to deal with the planet Venus (Hunger & Pingree 1999: 32), and by the time the transliteration by Reiner & Pingree used as the source for this investigation was compiled, it was already known from 20 different exemplars (Reiner & Pingree 1975: 7). The contents of the tablet (to be exact, its tenth omen) indicate that its original sources originated from the period shortly after the "Year of the Golden Throne," which is known to be the eighth year of the reign of the king Ammişaduqa (Hunger & Pingree 1999: 34). Several scholars have attempted to calculate the exact date in the modern calendar for this year, but most of the conclusions are completely different. The values range between 1500 and 2000 BCE (Hunger & Pingree 1999: 35), but the value of approximately 1650 BCE has received the most acceptance. It should be noted, however, that this is not the date for the compilation of the final tablet appearing in the *Enūma Anu Enlil* corpus – this only came into being in about 1000 BCE (Neugebauer 1969: 101).

The lines numbers and data appearing in the following section are derived from:

Reiner, E. & Pingree, D. 1975. *Babylonian Planetary Omens: Part One – The Venus Tablet of Ammisaduqa.* Malibu: Undena Publications.

The Venus Tablet of Ammişaduqa is made up of 59 different omens. These appear to be made up of four different sections, of which the first and third sections make up the bulk of the data. The fourth section repeats the omens of the first and third section, but arranges them in chronological order of months. The second section, on the other hand, deviates from the rest, and is in fact the section of most interest in terms of its astronomical content (Reiner & Pingree 1975: 7).

Most of the lines of the Venus tablet follow the same format, of which examples are given in the form of the first two omens:

1) On the 15th of Šabatu, Venus disappeared in the west, stayed away from the sky for three days, and on the 18th of Šabatu, Venus became visible in the East: Adad will bring his rain, Ea will bring his floods, kings will send other kings messages of reconciliation.

2) On the 11th of Arahsamnu, Venus disappeared in the east, stayed away from the sky for two months and (seven or eight) days, and on the 19th of Tebetu, Venus became visible in the west: the harvest of the land will prosper.

Omens, of course, are predictions. They follow a very basic if:then format, if you see something happing, it is a sign something specific will happen later. The “if” statement is known as the protasis; the “then” statement the apodosis (Hunger & Pingree 1999: 5). The omens of *Enūma Anu Enlil* follow this pattern, although in this sixteenth tablet, the protases are somewhat complex. The apodoses, however, are quite clear: rain and reconciliation for the first, prosperity for the second.

Within the omens, the planet Venus is described as disappearing and reappearing on certain days of the year. The reason for this is quite simple: planets of the solar system orbit around the Sun, but because they orbit it at different distance, it takes each one a different amount of time to complete each orbit. The planet Venus has a closer orbit to the Sun than the Earth, and, as such, will become invisible to the viewer when the three astronomical bodies form a straight line. When the planet is on the opposite side of the Sun to the Earth (known as the Superior Conjunction), the Sun obviously obscures the planet from view. When Venus is between the Sun and the Earth (Inferior Conjunction), while not being obscured, it will nevertheless not be visible due to the Sun’s brightness.

When Venus reappears in the sky, it will be visible on the horizon that day just before dawn. This is known as a *heliacal rising* (Koch-Westenholz 1995: 30), a term that will be used often within this investigation. Likewise, the last visible setting of a star at sunset before it disappears (since it now crosses the sky during bright daylight) is known as the *heliacal setting* (Koch-Westenholz 1995: 30).

The following is a list of data for the first 9 omens (and their repetitions), followed by the 10th omen which simply mentions the Year of the Golden Throne.

					Invisible				Visible	
Year	Omens		Heliacal setting		Months	Days	Heliacal rising		Months	Days
1	1	57	15	Šabatu		3	*18	Šabatu	8	23
2	2	52	11	Arahsamnu	2	*7	19	Tebetu	8	4
3	3	48	23	Ululu		20	13	Tešritu	8	19
4	4	43	2	!Tešritu	2	1	3	Ululu	x8	29
5	5	40	2	Ajjaru		*18	18	Ajjaru	x8	7
5	6	54	25	Kislimu	2	4	*29	Šabatu	8	29
6	7	51	!18	Arahsamnu		*3	1	Kislimu	8	20
7	8	46	21	Abu	2	11	2	Arahsamnu	8	23
8	9	44	25	Du'uzu		7	2	Abu	7	23
8	10		25	Addaru	Year of the Golden Throne					

Table 1: Venus Tablet data

It should be noted that periods of visibility are not listed on the tablet itself, they are calculated here in order to correlate the data with the values which will be presented from Tablet 64's second section.

The apodoses of the respective omens are as follows:

1) Adad will bring his rain, Ea will bring his floods, kings will send other kings messages of reconciliation.
2) The harvest of the land will prosper.
3) There will be hostilities in the land, the harvest will prosper.
4) The land will be happy.
5) There will be rains and floods, the harvest of the land will prosper.
6) The harvest of the land will prosper.
7) There will be scarcity of barley and straw in the land, there will be *ubbutu*
8) There will be rains in the land, there will be *ubbutu*
9) There will be rains in the land, there will be *ubbutu*

[*ubbutu* may refer to famine or desecration, but its translation is uncertain (Reiner & Pingree 1975: 13)]

By analyzing the data presented in these first tens omens, a few conclusions can be drawn about the nature of this text.

While the purpose of the text appears astrological, the nature of the information within the protases seems to be astronomical. The reason one can assume this is because it is too complex to be a regular protasis. In terms of omens using stellar phenomena as their protasis conditions, the format would generally require fewer constraints. In this instance, Venus' heliacal setting for a specific day of the year, its period of visibility and its heliacal rising are all noted. The identification of the data to real years of the reign of King Ammişaduqa also implies that these are records before being predictions. The systematic recording of phenomena in the night sky, in turn, is a factor of astronomical approach.

The data itself has a few interesting implications:

Periods when Venus is invisible are, as has been explained, when it is exactly between the Earth and the Sun and when the Sun is between it and the Earth. It remains invisible for only a short time during the inferior conjunction (when Venus is between the Sun and the Earth) and for longer at superior conjunction (when it is on the opposite side of the Sun to the Earth). This is clearly recorded in the text, with invisibilities jumping between single days and periods just over two months in length. However, Venus and the Earth both travel around the Sun at a constant speed. As such, the time it takes for them to return to the same relative positions to one another and the Sun should always be the same. In other words the time it takes between, for example, superior conjunction to the next superior conjunction should always be constant. This value is known as the *synodic period*, and will be discussed in greater detail in Section 5.2.2: [MUL.APIN Tablet II] Section XI: Planetary Visibility. In terms of the data for Tablet 16, that means that adding the periods of invisibility and the calculated values of visibility for each couplet of omens should always give the same value, but:

For Omens 1 & 2:
3 days + 8 months 23 days + 2 months 7 days + 8 months 4 days
= 18 months 37 days
= 19 months 7 days

For Omens 3 & 4:
20 days + 8 months 19 days + 2 months 1 day + 8 months 29 days
(Note that an intercalated month is added to the period of visibility for omen 4. Intercalation will be discussed at length in Section 4.2)
= 18 months 59 days
= 19 months 29 days

Clearly, the Babylonians did not yet realise at this stage how the planetary cycle worked. The observations, as such, could not have been very accurate. Inaccurate or not, the systematic nature of the data hints at the existence of an early scientific mind at work. Had the apodoses not been added to the end of each observation, this text would be indistinguishable from a true astronomical text. The apodoses in this text do not seem to be connected with the recorded data in any event – identical apodoses are allotted to several different omens in the text, as seen in the given section for omens 2 and 6, as well as 8 and 9, yet the omens with common apodoses do not share common heliacal risings, heliacal settings or periods of invisibility.

While the original scribe for this section may have been thorough in his observations (accuracy aside), both he and the scribes which copied the text after him made several mistakes. Omens 4 and 6 list incorrect month names (Reiner & Pingree 1975: 17-18 footnotes) and days respectively, and omens 1, 2, 5, 6 and 7 have different values in some exemplars.

Before any final conclusions can be drawn with regards to Tablet 64, however, the second system (used from omens 22 to 33) needs to be discussed. For this section, no table of data is necessary. For all the omens of this section, Venus rises in the east, remains visible for 8 months and 5 days, and then disappears for 3 months. After reappearing in the west, it remains visible for (once again) 8 months and 5 days and then disappears for 7 days (Reiner & Pingree 1975: 24).

There is no doubt that the second system was derived from a difference source to the other sections of Tablet 64, and its contents indicate a huge shift in understanding. It is clear that by the time this source was written it was understood that the synodic period of Venus was constant. The very existence of an altered system implies a striving for greater accuracy, and the quest for accurate understanding is one of the hallmarks of the scientific mind.

Enuma Anu Enlil may have been most prominent in the ancient world for its astrological function, but even there are these hints of a few scientific minds emerging from within its corpus. It would, however, take quite a long time between the recording of the data from the reign of Ammişaduqa in Tablet 64's source before the first true astronomical texts would appear.

4.2 ASTROLABES

The first truly astronomical texts, per se, were known as astrolabes. Before continuing with a discussion of the astrolabes, however, disambiguation is necessary, since the term has more than one meaning.

From the Concise Oxford Dictionary:
Astrolabe (noun) - An instrument formerly used in making astronomical measurements and in navigation for calculating latitude, consisting of a disc with the edge marked in degrees and a pivoted pointer.

This is entirely correct; the term “astrolabe” originally referred to a device most often found in the navigator’s room on ships. It consisted of a circular section, and had an astronomical function.

Astrolabes, in terms of ancient Mesopotamian studies, are entirely different… although they are still circular, and have astronomical functions. Mesopotamian astrolabes, however, were not used for navigation or the calculation of latitude, and most importantly, they were not instruments - they were tablets. According to Rochberg-Halton (1995: 1929), it is because of their similarity in depicting a cyclic returning of the stars to the same place (after a year has passed) that led to these texts being named “astrolabes.”

Several exemplars of the astrolabe texts have been identified and published. Amazingly, however, the very first astrolabe to be published was not a single tablet, but an astrolabe compiled from various fragments in the British Museum. It was published by a man named Pinches in 1934 (Van der Waerden 1949: 10), and remained the primary text for astrolabe studies for a long time.

The oldest knows astrolabe text is KAV 218, designated the Berlin Astrolabe, or Astrolabe B. It originates from the reign of Tigleth-Pileser I, close to the end of the second millennium BCE (Horowitz 1998: 155). It is highly suspected, however, that the first astrolabes were drawn up in the Middle Babylonian period, or even earlier. One passage of text from Astrolabe B can be linked to a much older Middle

Babylonian tablet, VAS 24120, while the system the astrolabes was based on appears in the Middle Babylonian Prayer to the Gods of the Night (Horowitz 1998: 158-159).

Astrolabe B is what is known as a list astrolabe, but the original astrolabes were actually round. To be more precise, they consist of three concentric rings. The astrolabe is then divided into 12 wedges of equal size, and thus one astrolabe is divided into 36 sections.

The top section of each wedge is given a label: a month of the year. The labels of the months follow on one another chronologically in a clockwise direction. Just underneath the month-label appears the name of a star, usually together with a number. Each of the 36 different sections of the astrolabe follows this pattern.

The following tables contain the information presented on a typical astrolabe (most of the data, apart from some variations of star names, remain constant for all exemplars, though not all contain numbers) with the sections of at the bottom of the table being the sections closest to the centre of the astrolabe. Those at the top are, in turn, closest to the rim. The tables progress as if being read in a clockwise direction. In the case of the stars, the ^{mul} determinative has not been included.

NISANNU	AJJARU	SIMANU	DU'UZU	ABU	ULULU
iku 3;20	mul 3;40	sipa.zi.an.na 4	kak.si.sá 3;40	ban 3;20	kalitum 3
dili.bat 1;40	šugi 1;50	ur.gu.la 2	maš.ta.ba 1;50	maš. ta.ba.gal 1;40	uga 1;30
apin 0;50	anunitum 0;55	muš 1	sag.me.gar 0;55	mar.gíd.da 0;50	šu.pa 0;45

Table 2.1: Astrolabes

TEŠRITU	ARAH-SAMNU	KISLIMU	TEBETU	ŠABATU	ADDARU
nin.mah 2;40	ur.idim 2;20	salbatanu 2	gu.la 2;20	nu.muš.da 2;40	ku6 3
zi.ba.an.na 1;20	gír.tab 1;10	ud.kah.duh.a 1	al.lul 1;10	sim.mah 1;20	neberu 1;30
en.te na.bar.hum 0;40	lugal 0;35	úz 0;30	te8.mušen 0;35	damu 0;40	ka5 0;45

Table 2.2: Astrolabes continued

The three concentric circles are described as representing the three paths of the sky, the Paths of Ea, Anu and Enlil. All the stars which can be found on the outer band belong to the Path of Ea, those in the middle band belong to the Path of Anu, and those closest to the centre of the astrolabe belong to the Path of Enlil.

To fully understand what these “paths” mean, it is important to in fact first jump to one of the many sections of our primary text, MUL.APIN, for a definition. Though they were already mentioned (at least by implication) in *Enuma Elish*, the Path of Ea, the Path of Anu and the Path of Enlil remain vague until a clarification is made.

In MUL.APIN Tablet II the following lines appear (Hunger & Pingree 1989: 88-89):

A.1 From the 1st of Addaru until the 30th of Ajjaru the Sun stands in the path of the Anu stars;
A.2 wind and weather.
A.3 From the 1st of Simanu until the 30th of Abu the Sun
A.4 stands in the path of the Enlil stars; harvest and heat.
A.5 From the 1st of Ululu until the 30th of Arahsamnu the sun
A.6 stands in the path of the Anu stars; wind and weather.
A.7 From the 1st of Kislimu until the 30th of Šabatu the Sun stands in the path
A.8 of the Ea stars; cold.

What this implies is that these “paths” are in reality bands across the sky, a way to divide the sky into different sections.

To state some basic planetary facts, since the Earth spins about its own axis, as areas of the Earth face the Sun they experience day, while those away from it experience night. At the equator, the sun appears to travel directly overhead, but the spherical nature of the Earth means that places in other latitudes view the sun from varying angles - areas further away from the equator experience a lower arcing Sun. For areas in the North, such as Mesopotamia, the noon sun would be visible in the southern sky.

If that was all there was to it, however, the Sun would always rise and set in exactly the same place. The Earth’s axis, however, is not at a perfect 90 degrees to its orbit, but rather tilted about 24° to the right (clockwise). For this reason, points on the Earth sphere are, at different times of the year (when the Earth is at different points in its orbit) actually at different distances from the Sun. At the same time, their relative position to the Sun, as well as the viewing angle, changes. For the Babylonians, situated in the northern hemisphere, they are closest to the Sun when the Sun appears to be at its northernmost declination in the sky.

Declination is a modern term, used to divide the sky up into measurable sections. What it entails is to map Earth’s own latitudinal lines into the sky. In other words, if you are standing on the equator, the centre of the Earth beneath your feet, everything directly above your head (stretching from one horizon to the next) lies on the celestial equator. From other parts of the Earth, this imaginary line shifts just like the path of the Sun shifts, sinking lower and lower into the sky towards the north in the southern hemisphere and to the south in the northern hemisphere, however, the starting points of the line are always due-east and due-west. The mid-point of this curved line is calculated by facing towards the appropriate direction in the sky (for Babylon, this would be south) and dividing everything ahead into 90 equal sections. With 90 at the top, the celestial equator will cross the point (90-current latitude), so, for example at the latitude of 35° North for Babylon, this would be at the point 55 increments above the horizon. Though not quite in the regular sense of the word, these increments are known as degrees, and the celestial equator is given the value 0, just like the equator of Earth. In a similar fashion, the other latitudinal lines can be determined in the night sky, and are measured by their difference in degrees with respect to the celestial equator – everything above it is positive, everything below is negative.

A star which rises on the starting point of the band +10° will follow that particular band until it sets, and so is a good indicator of which areas in the sky the look for a star (its counterpart, Right Ascension, together with which exact positions can be determined, is not of application to the Astrolabes).

While the rising and setting of the stars follows fixed routes, it has already been explained that the Sun tends to wander. On a daily basis, it still seems to travel along the paths of specific declinations, but over the course of the year it can be seen to have strayed. Its northernmost declination (for Babylon) occurs at the same time when the Sun is closest to the Earth, during the day of the Summer solstice, the longest day of the year. At the latitude of Babylon, the Sun appears to be rising at an angle 30° North of due East at this date (Horowitz 1998: 172), so +30°. During the equinoxes, when the length of day and night are the same, the Sun appears to rise and set due East-West, thereby following the celestial equator at 0°. With sunrise at Winter solstice, when the Sun is furthest away, it occurs at 30° South of due East (Horowitz 1998: 172), so -30°.

Analyzing the information obtained from MUL.APIN, additional information can be calculated. This text clearly divided the year into four different seasons; one of heat, one of cold, and two of moderate (to use the most positive derivation of “wind and weather”) temperatures. These seasons are exactly how we still define them, and as such the period of Simanu to Abu defines summer, Ululu to Arahsamnu autumn, Kislimu to Šabatu winter and Addaru to Ajjaru spring. These periods are all exactly three months long (which a comparison to the outer rim of the astrolabes can verify), and as such the seasons were of equal length.

MUL.APIN directly states that the Sun is in a different “path” of the sky during each of the different seasons. The only way in which such an equal division is possible is if these “paths” were similar to the bands of the sky used in determining modern star coordinates. If this is the case, the exact constraints of these paths should be calculable.

In summer, the Sun travels through the path of Enlil. As such, the path of Enlil is the northernmost of the 3 paths. During winter it travels through the path of Ea, thus this is the southernmost path. On its way through the sky the Sun naturally travels through due East twice throughout the year during spring and autumn, and this is exactly what it states in MUL.APIN – the Sun travels along the Path of Anu during two seasons.

During a year, the Sun will have travelled through its 60° range twice, as such, its travels a virtual 120°. There are four seasons of exactly the same length (3 months), so in one season, the Sun moves 30°. Summer does not start when the Sun is at its closest to the Earth and the temperature at its hottest, though – rather, the solstice occurs in approximately the middle of the season. As such, when the Sun is 30° north of due east, half of the summer has already passed, and as such the Sun would have already moved half of the declination for one season, 15°. As such, summer would have begun when the Sun was at +15°, and will end at exactly the same point. Exactly the same is true for winter, when the Sun is in the South. This leaves the declinations for autumn and spring between 15° North and 15° South of due East, which makes absolute sense, as the equinoxes thus occur (correctly) exactly when the Sun is due East (0°).

What this means for the three Paths is thus quite clear. The path of Anu should begin exactly in the centre of the sky if one is facing east, with its borders 15° to the left and right of this point. Since, according to the Astrolabe texts, as well as other sections of MUL.APIN, we are certain there are only 3 paths, the Sun’s limit of 30° North and South should be ignored as far as the other paths’ limits are concerned. It is only stated, that the Sun travels within these paths, not that it defines them. Rather, when facing east, everything to the left of the Path of Anu (in other words, everything north of it), lies in the Path of Enlil; everything to the right (in the South) is in the path of Ea. Since the path of Anu does not continue above the viewer’s head, but rather slants to the south to follow the celestial equator, the paths in fact have different shapes and sizes. While the Path of Anu is a slanted band across the sky, the Path of Ea is a small semicircle below it in the southern section of the sky, while the Path of Enlil encompasses the entire northern sky and everything above the viewer’s head.

The fact that the paths seem to focus on the southern sky is by no means strange – for an individual standing in the northern hemisphere, the southern sky is the area of most interest, with the highest concentration of stars. For stars to be visible from the surface of the Earth, they either need to be extremely large and bright objects, or relatively close (in astral terms). As such, the largest portion of stars visible from the surface are within the same galaxy (the Milky Way) as the Earth’s own solar system – this galaxy, like many, is round and flat, and so the object within it are also concentrated in a band. This band, like the celestial equator, is centred in the southern sky.

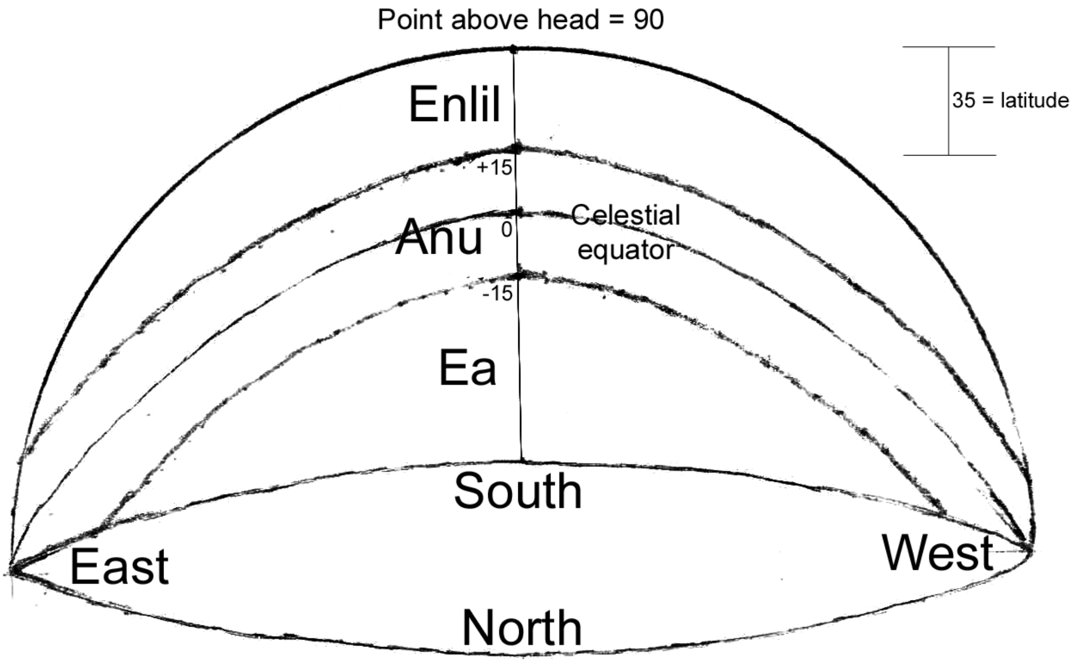

Figure 1: The Paths of Enlil, Anu and Ea

Returning to the astrolabes themselves, it is now clear that the stars closest to the rim are thus the stars visible in the southern parts of the sky, those closest to the centre are in the north, and those in the central band are basically in the middle.

The true name for astrolabes is actually “The three stars each.” The way the astrolabes are divided means that for each wedge, one star from each of the three paths is listed.

Each of those wedges, in turn, is labelled by a month name. Astrolabes, as such, are a form of calendar – each different month of the year is determined with the help of 3 stars. According to last section of Astrolabe B, the condition the stars in the appropriate section of the list need to fulfil is, in fact, to rise. In other words, a star listed in a section of the astrolabe will become visible for the first time that year during the morning just before sunset – it will rise heliacally.

This system of three stars representing a month is specifically mentioned in *Enuma Elish* tablet V, as mentioned in Section 3.1.1: Enuma Elish. To be mentioned in the epic of creation, it can be assumed that the system behind the astrolabes had an important function, and this is indeed the case.

The Babylonians defined months with respect to the Moon (Neugebauer 1947: 37). Months started just when the moon began to wax – just after new moon. As passage of four seasons took approximately 12 of these months, and thus this was designated as the period for one year. The problem, of course, was that a true year is not exactly 12 lunar months long. Lunar months, in fact, cannot be expressed in terms of finite numbers of days. An official Babylonian year of 12 lunar months was about 355 days long – 10 days too short.

What this meant is that over time, seasons would begin to shift, and activities based around them would no longer be predictable. People like farmers need to know exactly when to prepare the soil and plant their crops, and thus are extremely reliant on calendars. Astrolabe B’s menology section itself states that Ajjaru is the month to “turn the soil” and Du’uzu is the time to “pour the seed” (Horowitz 1998: 164).

Luckily, the Babylonians realised that the stars would return to the same positions at exactly the same time once every true year. The stars became markers for the calendar that should have been adopted in the first place. What would then occur is that when it was observed that the stars of the astrolabe rose a month late, an extra month was added to that year in order to realign the lunar and stellar calendars.

When viewing the astrolabes, the numbers below the names of the stars seem to be an odd addition. Fortunately, similar schemes appear in other texts, including MUL.APIN, and can therefore be explained without too much of a problem.

The numbers on the list are generally referred to as *minas* and *shekels* in the list form astrolabes. *Mina* is the term used for a weight of water that was used to measure time by means of a special instrument known as a water clock. These weights of water were poured into the clepsydra (bowl) of the instrument, which then emptied from it by means of an opening or hole (Fermor & Steele 2000: 211). Though *minas* are actually the weights of the water, they can also be used as the time unit itself (since the weights always take the same amount of time to empty). The Babylonians preferred to base their numerical systems on a base of 60, and in this way there are 60 *shekels* in one *mina*. One and a half *mina* is thus denoted as 1;30. This form of annotation is a modern construct, though. Early Babylonian numerical texts require considerable patience to decipher, since often numbers like 3, 180 (3x 60) and 10800 (3x60x60) are all simply written as 3 (Neugebauer 1969: 15-16).

Taking this into account, it is clear that the numbers of the middle ring are simply half of those for the same month in the outer ring; the same is true for the inner ring equalling half of the middle ring (thus a quarter of the outer ring) – they simply indicate half watches and quarter watches (‘watch” is the term used to imply the entire day or night respectively). Of more general interest is the progression of these numbers throughout the months. By using the outer ring as a base, the value is highest for Simanu, at 4 *minas*. It decreases at a constant rate every month until reaching its lowest point during Kislimu, at 2 *minas*, exactly 6 months after its original peak. The values then start rising again (keeping the same rate) until Simanu of the next year.

The exact implications of these values can be stolen from the primary text, MUL.APIN, when it declares for a very similar system:
“4 minas is a daytime watch, 2 minas is a night-time watch”

The numbers visible on the astrolabes in fact represent the hours of daylight, which are at their longest, according to this scheme, during Simanu. Simanu is indeed during the Babylonian summer, and as such the day of longest daylight (the summer solstice) is likely what is represented by the 4 *minas*. The shortest amount of daylight, as such, will occur during Kislimu.

This data is, however, not very accurate. The ratio for the longest to the shortest day is here 2:1, but for the latitude of Babylon, a ratio of 3:2 would be more accurate, and a ratio of 7:5 would be close to the truth (Fermor & Steele 2000: 211). Neugebauer (1947: 39) attempts to explain this discrepancy by explaining that the rate water empties from most containers is not constant, but rather depends on the weight of the water still in the container. He arrives at a value which in fact implies that the 4:2 *mina* ratio actually really does empty in a 3:2 time ratio. As logical as this sounds, it is in fact at opposition with the data, since this ratio of emptying would result in an inconstant rate of change.

In terms of accuracy, however, there are a few issues with the astrolabe texts which need to be mentioned. First of all: with respect to the Paths of Ea, Anu and Enlil as defined in MUL.APIN, many of these constellations are listed under the wrong sections. Of course, since the astrolabes are older than MUL.APIN, the system was perhaps not quite as refined yet. For the most part, the astrolabes hold true if one considers the constellation listed under Enlil to be the northernmost of the three listed, and that listed under Ea to be the southernmost of the three listed. As such, the constellations may have been chosen more for their relative positions rather than their existence in a defined band.

Secondly: some of the stars listed, like $^{\mathrm{mul}}$dili.bat and $^{\mathrm{mul}}$sag.me.gar, are planets. Planets do not rise in the same month every year, and as such cannot rightly function as indicators for months. According to tradition, however, this is how things should be, since Marduk set up his own station $^{\mathrm{mul}}$sag.me.gar (Neberu / Jupiter) to be the watcher over the rest of the stars, and set the stations of Anu and Enlil to accompany it (Ee V: 5-6). It can only be assumed that the other planets may have also been included due to tradition, since they do not fit the necessary criteria otherwise.

As the first truly astronomical texts, the astrolabes do not disappoint. While not quite as complex and rich in information as the texts which followed, they provide enough to be clear and fulfil their purpose. For the first time, there are also hints of the development of scientific thought patterns with respect to texts. For intercalations schemes, the amount of information required is not actually very much. The heliacal rising dates of 12 different stars could just as easily serve the same purpose. However, the creator of the original astrolabe found it necessary not only to provide multiple alternatives, but also to systematise them. The division of the constellations into separate regions is an exercise in categorization, showing interest in the observed phenomena. The addition of the data from the water clocks only goes to argue that the individual was extremely thorough, since these values were not necessary for the greater purpose, they were simply an alternative method of calculating the same things (instead of watching for star risings, daylight could be measured).

Before proceeding with the primary text, one last point needs to be mentioned about the Astrolabes. A few broken texts, such as K6087 (Van der Waerden 1949: 11) list some of the astrolabe stars under the headings “The Stars of Elam”, “The Star of Akkad” and the “Stars of Amurru.” The stars are listed as rising in the correct order (Van der Waerden 1949: 11) but the division of the stars between the three paths does not follow, and the stars are not given risings dates. The Astrolabes could possibly have originated from these texts, but the texts themselves are too fragmentary to obtain anything more than a suspicion.

5. MUL.APIN

While the astrolabes and even *Enuma Anu Enlil* show some signs of emerging scientific views and methodology, the primary focus of this investigation is on a text known as MUL.APIN.

MUL.APIN owes its discovery, or at least identification, like most of the texts discussed so far, to L.W. King. In his 1912 publication, *Cuneiform Text from Babylonian Tablets*, he published tablet BM 86378 via 8 plates (Hunger & Pingree 1999: 57). Its contents immediately sparked the interests of several scholars, including Father X. Kugler, famous amongst his contemporaries and later scholars for his work with the later mathematical astronomy texts (the work in question being a 1909 publication, *Sternkunde* - for praises of his work see, for example, Olmstead 1938: 113). More importantly, it also sparked the interest of E.F. Weidner, who made it a mission to locate more exemplars of this text (Hunger & Pingree 1989: 3) and with great success. These and other scholars published many discussions and interpretations, all the while continuing the search for more tablets. A. Sachs, who knew about Weidner's interest, also identified many British Museum tablets as being a part of this text, and sent Weidner the transcriptions (Hunger & Pingree 1989: 3).

What makes MUL.APIN so remarkable is that it is, in its most simple definition, a compilation of astronomical data. Although the connection of the stars to various gods is mentioned and there is a small section on omens, the majority of the text focuses on that which could actually be seen. MUL.APIN is a compendium of all that was (believed to be) known, via observation or basic calculation, about the bodies of the night sky, up until the point of its compilation – there is evidence for the use of a multitude of different sources within its contents.

MUL.APIN spans across two tablets, of which only the first was published by King back in 1912. The second would only be published 12 years later (Hunger & Pingree 1999: 57). As with cuneiform texts in general, the text is named after the first words which appear on it, in this case being $^{\text{mul}}$APIN, the constellation (or simply "star") of the Plough. Its name is confirmed in the colophons (colophons being sections visibly separated from the rest of the text, often by a line, and usually at the bottom of the tablet) of several of the exemplars, amongst others the original BM 86378 (Hunger & Pingree 1989: 123). Ironically, though many other tablets have been found, this first text's clarity of lines and the fact that it is largely complete ensures that it remains the basis for all the following texts. It is also most likely the most similar to the original compilation of the text, since it specifically designates itself as "Tablet 1" (Hunger & Pingree 1989: 8) and fits well in terms of content division with the tablet believed to be closest to the original version of Tablet 2, BM42277 (which similarly calls itself Tablet 2 of MUL.APIN) (Hunger & Pingree 1989: 8). Both are divided into four columns.

To give a date to MUL.APIN is not simple, though the exact dates of two exemplars are known from their colophons. The earliest of these is from VAT 9412+11279: stated to be written by the self proclaimed "small apprentice scribe" Nabû-rešu-iši, during the Eponymy of Sennacherib (Hunger & Pingree 1989: 123), giving the exact date of 686 BCE. The later dated text originates from the reign of Seleucus. Though the date is not stated on the tablet itself, the originally published BM 86378 is estimated to have been copied in about 500 BCE (Hunger & Pingree 1989: 123).

Although the oldest confirmed date comes from the 7th century BCE, this does not mean that MUL.APIN was compiled during this period. The chances are good that it is a bit older. MUL.APIN, first of all, was a popular (or at least important) text in antiquity. Evidence from other written sources is available (sections from MUL.APIN are used and quoted in other texts), but the most obvious evidence is that when Hunger & Pingree compiled their 1989 translation of the text, they were able to make use of 40 different exemplars (Hunger & Pingree 1989: 3-4). Admittedly, this is split into 28 versions of tablet I and 12 of tablet II, but the exemplars have different origins. Only a fraction of all written texts survive – most texts, such as those quoted in the section on creation myths (barring *Enuma Elish* itself, of course) only are known from one or two existing tablets. Naturally, many may simply be lost in a museum storeroom somewhere, and Weidner's drive to find more copies led to many seeing the light of day when otherwise they would have suffered the same fate. Even then, 40 is a high number.

This high total usually does not imply that several copies were made at once, but rather that it was re-copied over time. This is usually evident in textual changes between examples, creating time-based variations, though the list-nature of the data presented has meant that this was not the case. The only real differences between versions comes from the fact that 24 of the known tablets were written in Babylonian script, while the other 16 were written in Assyrian script (Hunger & Pingree 1989: 3-4).

For most texts, discerning a date of origin is next to impossible. Dates for exemplars can obtained through, for example, relative dating (such as comparing objects found in the same excavation level to approximate a date), but to date the origin of a text itself one would require knowledge of some form of calculable phenomenon, such as the position of the stars at the time of its writing… which is exactly what a majority of MUL.APIN itself is dedicated to, the positions of the stars in the heavens.

MUL.APIN’s own content would have been the best form of evidence possible for dating, but as it turns out, things are not that simple.

Exactly how the following dates were determined will be explained after the data of the subsequent sections used has been investigated, but the most promising conclusion is that from Reiner & Pingree’s (1981) publication *Babylonian Planetary Omens II*, that the majority of the data from MUL.APIN comes from the period 1000 BCE, and was taken from a latitude of 36 degrees north, in Assyria. However: this is believed to be the oldest data, and not all the data can be said to originate from this time. As has been stated, MUL.APIN is a compilation drawn up from a variety of sources, some even contradicting others in the information they present. As such, the date of compilation is not reliant on the dating of the information, though admittedly knowing the date of the youngest source would help to at least narrow down the range in which the compilation could be carried out (i.e. between the date of youngest source and 686 BCE, the youngest possible date). Sadly, only some of the sources present data such can be used to calculate their dates of origin; the youngest date is impossible to calculate. It should also be remembered that the sources used to compile MUL.APIN would have come out of the Astronomical Library in Babylon, where the majority of such texts were collected, and could have been several hundred years old by the time of their inclusion. Fortunately, as far as analysis is concerned, the dating of the contents is more important than the dating of the compilation, and, as has been stated, such dates can be calculated via the contents itself.

The contents of MUL.APIN can be divided into multiple different sections, each section usually pertaining to a different source used, though the text itself does not distinguish between them. Instead, it is up to the reader to group the relevant information. In order to answers the questions regarding the Babylonian conceptualization of the sky (what they knew, what they believed and what they saw) each of these sections will be dealt with separately.

As previously mentioned, the translation which shall be used henceforth for MUL.APIN comes from:

Hunger, H. & Pingree, D. 1989. *MUL.APIN. An Astronomical Compendium in Cuneiform*. Horn: Verlag Ferdinand Berger & Sohne.

This translation makes use of column and line numbers derived from BM 86378, of which here is quoted in the form “iii.5”, of which the lowercase roman numerals (iii) indicate the column number, followed by the line number. Tablets I and II will be dealt with separately, and as such Tablet II begins again with i.1.

5.1 TABLET I

5.1.1 SECTION I: STAR LIST

The first section of MUL.APIN spans 79 lines - the entire first column of the first tablet and the first 35 lines of the second column. It soon becomes apparent that what is presented here is a systematic classification of heavenly bodies: Line 39 of column 1, as well as lines 18 and 35 of column 2, make it clear that the purpose of this list is to divide up the constellations (though sometimes single stars) according to the different Paths in the sky in which one can find them; the aforementioned Paths of Enlil, Anu and Ea from the Astrolabes.

Unlike the Astrolabes, however, there are not only 12 stars inserted into each path. The Astrolabes had a very specific function, after all, in helping people to determine the different months of the year via the use of the 3-star/constellation rising, whereas the Star List seems to have been created for little other purpose than classification. The uneven amounts of constellations in each Path are evidence of this, what is in the list is what is simply what is seen; visible reality.

Following the name of the star, in each case, is the name of the god that star/constellation is associated with. Despite the fact that scholars attempt to classify MUL.APIN as a purely astronomical text, the stars were still most certainly associated with the gods as had been done prior to, and following, the compilation of this text.

Since it is fairly certain that the three paths encapsulated the entire sky, the Star List is in fact a list of every constellation known to the Babylonians (or Assyrians, as the case may be for this particular section) at the time. As such, it provides the greatest insight into what they believed they could see within the sky at night. As such, after the introduction of the line, the original name of the constellation will be given, as well as a list of modern stars thought to belong to the constellation in question (as quoted from the list of modern star equivalents used in the primary translation (Hunger & Pingree 1989: 137 – 138)). These modern associations, of course, cannot be verified with absolute certainty, since most were calculated with the assistance of later sections of MUL.APIN itself. This will be explained in more detail under the appropriate sections.

5.1.1.1 THE PATH OF ENLIL

i.1. The Plough, Enlil, who goes at the front of the stars of Enlil.
Original name: ^{mul}APIN
Modern stars: [α, β Trianguli (possibly also γ Trianguli), γ Andromedae]

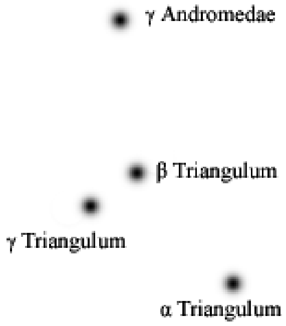

Figure 2: The Plough constellation

i.2. The Wolf, the seeder of the Plough.
Original name: ^{mul}UR.BAR.RA
Modern stars: [α Trianguli]

i.3. The Old Man, Enmešarra.
Original name: ^{mul}ŠU.GI
Modern stars: [Equal to modern Perseus]

i.4. The Crook, Gamlum.
Original name: ^{mul}GÀM
Modern stars: [Equal to modern Auriga]

i.5. The Great Twins, Lugalgirra and Meslamtaea.
Original name: ^{mul}MAŠ.TAB.BA.GAL.GAL.LA
Modern stars: [Equal to modern Gemini]

i.6. The Little Twins, Alammuš and Nin-EZENxGUD.
Original name: ^{mul}MAŠ.TAB.BA.TUR.TUR
Modern stars: [ζ, λ Geminorum]

i.7. The Crab, the seat of Anu.
Original name: ^{mul}AL.LUL
Modern stars: [Equal to modern Cancer]

i.8. The Lion, Latarak.
Original name: ^{mul}UR.GUL.LA
Modern stars: [Approximately equal to modern Leo, but with single stars from Virgo]

i.9. The star which stands in the breast of the Lion: the King.
Original name: ^{mul}LUGAL
Modern stars: [α Leonis, also commonly known as Regulus]

i.10. The dusky stars which stand in the tail of the Lion.
Original name: KUN ^{mul}UR.GUL.LA
Modern stars: [Possibly 5 or 21 Leonis]

i.11. The Frond of the date palm of Eru, Zarpanitu.
Original name: GUB-zu
Modern stars: [γ Comae Berenices]

i.12. ŠU.PA, Enlil who decrees the fate of the land.
Original name: ^{mul}ŠU.PA
Modern stars: [Equal to modern Boötes, or perhaps only part of it]

i.13. The star which stands in front of it: the Abundant One, the messenger of Ninlil.

Original name: ^{mul}Hè-gál-a-a-ú

Modern stars: [Possibly β Comae Berenices]

i.14. The star which stands behind it: the Star of Dignity, the messenger of Tišpak.

Original name: MUL BAL.TÉŠ.A

Modern stars: [Corona Borealis]

i.15. *The Wagon, Ninlil.

Original name: ^{mul}MAR.GÍD.DA

Modern stars: [Ursa Major]

i.16. *The star which stands in the cart pole of the Wagon

i.17. the fox, Erra, the strong one among the gods.

Original name: ^{mul}KA$_5$.A

Modern stars: [Perhaps 80-86 Ursae Maioris]

i.18. *The star which stands in front of the wagon, the Ewe, Aya.

Original name: ^{mul}U$_8$

Modern stars: [Perhaps the north-eastern section of Boötes]

i.19. *The Hitched Yoke, the great Anu of Heaven.

Original name: ^{mul}MU.BU.KÉŠ.DA

Modern stars: [Perhaps α Draconis]

i.20. *The Wagon of Heaven, Damkianna.

Original name: ^{mul}MAR.GÍD.DA.AN.NA

Modern stars: [Ursa Minor]

i.21. *The star which stands in its rope: the Heir of the Sublime Temple,

i.22. the first ranking son of Anu.

Original name: ^{mul}IBILA.É.MAH

Modern stars: [Probably α Ursae Minoris]

i.23. (1) The Standing Gods of Ekur, (2) the Sitting Gods of Ekur.

(1) Original name: ^{mul}DINGIR.GUB.BA (^{meš}šu-ut É-kur)

Modern stars: [Possibly ζ, η Herculis]
(2) Original name: ^{mul}DINGIR.TUŠ.A (^{meš}šu-ut É-kur)
Modern stars: [μ Virginus]

i.24. The She-Goat, Gula.
Original name: ^{mul}ÚZ
Modern stars: [Equal to modern Lyra]

i.25. The star which stands in front of the She-Goat: the Dog.
Original name: ^{mul}UR.KU
Modern stars: [Part of the southern section of modern Hercules]

i.26. The bright star of the She-Goat: Lamma, the messenger of Baba.
Original name: MUL né-bu-ú: ^{d}LAMMA
Modern stars: [α Lyrae]

i.27. The two stars which stand behind it: (1) Nin-SAR and (2) Erragal.
2 MUL^{meš},
(1) Original name: ^{d}Nin-SAR
Modern stars: [ε Lyrae]
(2) Original name: ^{d}Èr-ra-gal
Modern stars: [ζ Lyrae]

i.28. The Panther: Nergal.
Original name: ^{mul}UD.KA.DUH.A
Modern stars: [The entire modern constellations of Cygnus and Lacerta, including parts of Cassiopeia and Cepheus]

i.29. The star which stands at its right side: the Pig, Damu.
Original name: ^{mul}ŠAH
Modern stars: [Most likely sections of modern Draco, including the head and first coil]

i.30. The star which stands at its left side: the Horse.

Original name: ^{mul}ANŠE.KUR.RA
Modern stars: [α, β, γ, δ Cassiopeiae]

i.31. The star which stands behind it: the Stag, the messenger of the Stars.
Original name: ^{mul}lu-lim
Modern stars: [Eastern section of modern Andromeda]

i.32. The dusky stars which stand in the breast of the Stag
i.33. Harriru, the Rainbow.
Original name: MUL^{meš} um-mu-lu-tu$_4$, ^{d}Hari-ri-ru ^{d}TIR.AN.NA
Modern stars: [Perhaps 18, 31, 32 Andromedae]

i.34. The bright red star which stands in the kidney of the Stag,
i.35. The Deleter.
Original name: ^{mul}KA.MUŠ.Ì.KÚ.E
Modern stars: [β Andromedae]

i.36. When the stars of Enlil have been finished,…..
i.37. one big star, although its light is dim, divided the sky in half and stands there: the star of Marduk, the Ford,…..
i.38. Jupiter, it keeps changing its position and crosses the sky.
Original name: MUL ^{d}AMAR.UD né-bi-ri = kakkab Marduk Nēberu,
^{mul}SAG.ME.GAR
Modern stars: [The planet, Jupiter]

i.39. 33 stars of Enlil.

Thirty three is the highest number of stars listed amongst the different paths, which of course makes absolute sense. According to the calculations made in the Astrolabe section, this path encompasses the greatest portion of the sky. The stars and constellations quoted from lines 15 to 21 are in fact circumpolar stars (Hunger & Pingree 1989: 137), of which the circular paths in the sky are so high that they never set over the horizon. It is unfortunate that this cataloguing of stars, an activity which likely originated from a mind craving systemization, is nevertheless burdened by what can only be assumed to be a forced inclusion of ^{mul}SAG.ME.GAR (the planet Jupiter) to the end of this path. Despite the fact that later sections of MUL.APIN (Section VIII: The Ecliptic Continued – Planets) attest that the scribes of the time recognised that all the different planets followed the same paths through the sky, Jupiter was most likely separated from the rest and included into the Path of Enlil due to its connotations as Nēberu, the star of Marduk (Brown 2000: 116). Having it introduced as an Enlil star in *Enuma Elish,* the formal creation myth of the time (more specifically, it is stated as the star completing the trio of stars, of which the others are Stars of Anu and Ea, as discussed in Section 3.1.1: Enuma Elish), meant that the social pressures to keep it in this path would have made it impossible to contradict.

5.1.1.2 THE PATH OF ANU

i.40. The Field, the seat of Ea, which goes at the front of the stars of Anu.
Original name: ^{mul}AŠ.IKU
Modern stars: [α, β, γ Pegasi, α Andromedae]

i.41. The star which stands opposite the field: the Swallow.
Original name: ^{mul}Ši-nu-nu-tu$_4$, also often referred to as ^{mul}Šim.mah
Modern stars: [ε, ζ, θ Pegasi, possibly α Equulei, as well as large portion of modern Pisces (the entire western fish)]

i.42. The star which stands behind the field: Anunitu.
Original name: ^{mul}A-nu-ni-tu$_4$
Modern stars: [A large portion of modern Pisces (the eastern fish and the stars joining it to the western fish)]

i.43. The star which stands behind it: the Hired Man, Dumuzi.
Original name: $^{mul\ lú}$HUN.GÁ
Modern stars: [Equal to modern Aries]
i.44. The Stars, the seven gods, the great gods.
Original name: MUL.MUL
Modern stars: [Equal to modern Pleiades, adding η Tauri)

ii.1. (1) The Bull of Heaven, (2) The Jaw of the Bull, the crown of Anu
(1) Original name: $^{\text{mul}}$GU$_4$.AN.NA
Modern stars: [Equal to modern Taurus]
(2) Original name: $^{\text{mul}}$is le-e
Modern stars: [α Tauri and the Hyades]

ii.2. The True Shepherd of Anu, Papsukal, the messenger of Anu and Ištar.
Original name: $^{\text{mul}}$SIPA.ZI.AN.NA
modern stars: [Equal to modern Orion]

ii.3. The Twin Stars which stand opposite the Shepherd of Anu:…..
ii.4. …..Lulal and Latarak.
Original name: $^{\text{mul}}$MAŠ.TA.BA – $^{\text{d}}$LÚ.LÀL, $^{\text{d}}$La-ta-ra-ak
Modern stars: [Possibly π^3 and π^4 Orionis]

ii.5. The star which stands behind it: the Rooster.
Original name: $^{\text{mul}}$DAR.LUGAL
modern stars: [Equal to modern Lepus]

ii.6. The Arrow, the arrow of the great warrior ninurta.
Original name: $^{\text{mul}}$KAK.SI.SÁ
modern stars: [The entire modern constellations of Manis Major and Canis Minor, and well as sections of Puppis and Pyxis]

ii.7. The Bow, the Elamite Ištar, the daughter of Enlil.
Original name: $^{\text{mul}}$BAN
Modern stars: [δ, ε, σ, ω Canis Minoris and κ Puppis]

ii.8. The Snake, Ningizzida, lord of the Netherworld.
Original name: $^{\text{mul d}}$MUŠ
Modern stars: [Equal to modern Hydra]

ii.9. The Raven, the star of Adad.
Original name: $^{\text{mul}}$UGA$^{\text{mušen}}$

Modern stars: [Equal to the entire modern constellations of Corvus and Crater]

ii.10. The Furrow, Sala, the ear of corn.

Original name: ^{mul}AB.SÍN

Modern stars: [Equal to modern Virgo]

ii.11. The Scales, the horn of the Scorpion.

Original name: ^{mul}ZI.BA.AN.NA

Modern stars: [Equal to modern Libra]

ii.12. (1) The star of Zababa, (2) the Eagle, (3) the Dead Man

(1) Original name: MUL ^{d}Za-ba$_4$-ba$_4$

Modern stars: [This is difficult to define, but seems to include parts of Opiochus, Serpens and a single star from Aquila, λ Aquilae]

(2) Original name: ^{mul}TI$_8$^{mušen}

Modern stars: [Equal to modern Aquila]

(3) Original name: ^{mul}AD$_6$

Modern stars: [Possibly equal to modern Delphinus]

ii.13. *Venus keeps changing its position and crosses the sky.

Original name: ^{mul}Dili-bat

Modern stars: [The planet Venus]

ii.14. *Mars keeps changing its position and crosses the sky.

Original name: ^{mul}Ṣal-bat-a-nu

Modern stars: [The planet Mars]

ii.15. *Saturn keeps changing its position and crosses the sky.

Original name: ^{mul}UDU.IDIM.SAG.UŠ

Modern stars: [The planet Saturn]

ii.16. *Mercury, whose name is Ninurta, rises or sets in the east

ii.17. or in the west within a month.

Original name: ^{mul}UDU.IDIM.GU$_4$.UD

Modern stars: [The planet Mercury]

ii.18. 23 stars of Anu.

As expected, the Path of Anu holds less important stars/constellations than the Path of Enlil, since its area is smaller. As is noted in the translation’s astronomical commentary, the very first star listed of this Path actually is actually associated in the mythological/religious sense with god of the next path, Ea, since the religious connotations of the separate stars would have been in place before the systematic division of the sky (Hunger & Pingree 1989: 139). Notably, all of the planets known to the ancient Babylonians (barring Jupiter) are also listed in this path. The route the planets follow in fact entails that they do stray from this path sometimes, but since they would be in this most of the time, it is the path with which they are associated.

5.1.1.3 THE PATH OF EA

ii.19. The Fish, Ea, who goes at the front of the stars of Ea.
Original name: $^{\text{mul}}$KU$_6$
Modern stars: [Equal to modern Pisces Austrinus]

ii.20. (1) The Great One, Ea, (2) the star of Eridu, Ea.
(1) Original name: $^{\text{mul}}$GU.LA
Modern stars: [Equal to modern Aquarius]
(2) Original name: $^{\text{mul}}$NUN$^{\text{ki}}$
Modern stars: [Contains parts of modern Puppis and Vela]

ii.21. The star which stand at its right: Nin-mah.
Original name: $^{\text{mul}}$Nin-mah
Modern stars: [Contains parts of modern Vela]

ii.22. Habaşirānu, Ningirsu.
Original name: $^{\text{mul}}$EN.TE.NA.BAR.HUM
Modern stars: [A large portion of modern Centaurus]

ii.23. The star which stands at its side: the Harrow, the weapon of Mar-biti,
ii.24. inside of which one sees the subterranean waters.
Original name: $^{\text{mul giš}}$GÁN.ÙR
Modern stars: [The eastern section of modern Vela]

ii.25. The two stars which stand behind it: (1) Šullat and (2) Hanis, Šamaš and Adad.
(1) Original name: 2 MUL$^{\text{meš}}$ – $^{\text{d}}$Šullat
Modern stars: [Possibly μ Centauri]
(2) Original name: $^{\text{d}}$Haniš
Modern stars: [Possibly either ε or υ Centauri]

ii.26. The star which stands behind them rises like Ea
ii.27. Numušda, Adad.
Original name: $^{\text{mul}}$Nu-muš-da
Modern stars: [η or κ Centauri]

ii.28. The star which stands at the left side of the Scorpion: the Mad Dog, Kusu.
Original name: $^{\text{mul}}$UR.IDIM
Modern stars: [Equal to modern Lupus, with possible additions of stars from Scorpius]

ii.29. The Scorpion, Išhara, goddess of all inhabited regions.
Original name: $^{\text{mul}}$GÍR.TAB
Modern stars: [Equal to modern Scorpius]

ii.30. The Breast of the Scorpion: Lisi, Nabû.
Original name: $^{\text{mul}}$GABA GÍR.TAB
Modern stars: [α Scorpii]

ii.31. The two stars which stand in the sting of the Scorpion
ii.32. (1) Šarur and (2) Šargaz.
(1) Original name: 2 MUL$^{\text{meš}}$ – $^{\text{d}}$Šár-ur$_4$
Modern stars: [λ Scorpii]

(2) Original name: ^{d}Šár-gaz
Modern stars: [υ Scorpii]

ii.33. The star which stands behind them: Pabilsag.
Original name: ^{mul}Pa-bil-sag
Modern stars: [The entire modern constellation in Sagittarius, as well as parts of Opiochus]

ii.34. (1) The Bark and (2) the Goat-Fish.
(1) Original name: ^{mul}MÁ.GUR$_{8}$
Modern stars: [ε Sagitarii]
(2) Original name: ^{mul}SUHUR.MÁŠ^{ku6}
Moderns stars: [The entire modern constellation of Capricorn]

ii.35. 15 stars of Ea.

The Path of Ea holds the least amount of important stars or constellations as predicted, since its area is even smaller than the Path of Anu.

The first section of MUL.APIN, as a catalogue, is already a sign of emerging scientific tendencies. The systematic classification and categorization of the aspects of the universe is one of the prime aspects of science itself. Sadly, as has been stated, this scientific approach did have to accept compromises with respect to the classification of the star of the primary god at the time, Marduk, in order not to cause unnecessary trouble for the scribe.

5.2.2: SECTION II: HELIACAL RISINGS

As has been explained in Section 4.1: Enuma Anu Enlil, not all stars and constellations can be seen at the same time. They appear on the eastern horizon one morning, though can obviously only be observed briefly before the light of the Sun hides them from view. Every day they rise slightly earlier, and after some time, these stars can be seen during the night, eventually disappearing again over the western horizon and remaining invisible again for some time.

Line 36 of column 2 reads: “On the first of Nisannu the Hired Man becomes visible.” It is followed by several more lines of exactly the same style, listing a date and stars/constellations becoming visible, up until line 12 of column 3. Even from the first line, it is clearly evident that what is being presented is a list of dates on which certain stars become visible in the sky, and line 42 of column 2 and lines 8-9 of column 3 clarify this even further: one constellation, the Arrow, is mentioned twice in the list - on the 15 of Du’uzu it is said to become visible, following the same pattern as the rest of the stars, while on 15 Tebetu it is specifically mentioned as now being visible during the evening. Since the other entries follow the pattern as mentioned for the Bow on 15 Du’uzu, it is confirmed that Section II lists the heliacal rising of stars: the time of their first visibility on the eastern horizon.

The information presented in this section can be summarized as follows:

Date of Heliacal Rising	Stars / Constellations appearing
1 Nisannu	Hired Man
20 Nisannu	Crook
1 Ajjaru	Stars
20 Ajjaru	Jaw of the Bull
10 Simanu	True Shepherd of Anu; Great Twins
5 Du’uzu	Little Twins; Crab
15 Du’uzu	Arrow, Snake, Lion – 4 minas is a daytime watch, 2 minas is a night-time watch.
5 Abu	Bow; King
1 Ululu	(broken in all exemplars)
10 Ululu	Eridu, Raven
15 Ululu	ŠU.PA (Enlil)
25 Ululu	Furrow
15 Tešritu	Scales, Mad Dog, Habaşirānu, Dog 3 minas is a daytime watch, 3 minas is a night-time watch.
5 Arahsamnu	Scorpion
15 Arahsamnu	She Goat, Breast of the Scorpion
15 Kislimu	Panther, Eagle, Pabilsag
15 Tebetu	Swallow, Arrow now visible in the evening 2 minas is a daytime watch, 4 minas is a night-time watch
5 Šabatu	Great One, Field, Stag

25 Šabatu	Anunitu
15 Addaru	Fish, Old Man

Table 3: Heliacal Risings

In arguing that the Babylonian approach to astronomy was at least partially scientific, this section shows a bit of promise. As with the first section, it is an exercise in classification. This time around, that classification is systemised even further by presenting the information in clearly chronological order (the order of the Babylonian months already being known from other texts). More importantly, however, is that this section has practical applications – on the first of Nisannu, it is not stated that the Hired Man "became" visible, but that it "becomes" visible – the text is meant to be used as a reference for the dates when the constellations become visible every year. In a sense, it is like an Astrolabe focusing on the use of single stars, but can be used to determine more specific dates rather than just the current month. Having mentioned the astrolabes, it is important to note that section II lists day and night watches for the colures (equinoxes and solstices), just like the astrolabes, and in all the sections of MUL.APIN these dates have all shifted backwards by one month (to be more precise, the months have all been shifted forward). It can only be assumed that this was caused by a formal alteration of the calendar by the administration, and as such falls outside the scope of this investigation. Unlike the first section, there is no inclusion of information that could be tied to religious beliefs, a factor which is so often brought up in arguments against scientific thinking.

But, while section II does support the desire for classification and systemisation of knowledge - hints of a scientific mind – it also introduces an aspect of thought which the "true" scientific mind frowns upon: generalisation, or more accurately, approximation.

The dates of the different heliacal risings, in each instance, seem to be rounded off - usually to the nearest 5. In a few instances, entries appear for the first of the month, but these could just as well have been made for the last day of the previous month (which, as shall be explained shortly, is considered the 30th for all the different sections). Any systematic person, when asked to arrange data, will attempt to start from a well-defined point, and so one can infer that the scribe of this section’s original source may have set his 30s to 1s simply so that he could start on the date of the new year, 1 Nisannu.

Nevertheless, the simple fact is that stars are not grouped in such an orderly way that the constellations people believe to see in them all rise perfectly within five days of one another. This imperfection also creates a situation where it is rare for constellations to rise at the same time, yet section II has, in some instances, three rising on exactly the same date. As far as the search for the nature of the stars in terms of scientific principals goes, deliberate approximation is a serious fault.

5.2.3 SECTION IV: HELIACAL RISINGS CONTINUED

Before continuing the investigation of the second section, it is prudent to skip straight ahead to the fourth, since the information contained within it is extremely similar to that found in section II of Heliacal Risings.

Section IV spans from column 3, line 34, to column 3, line 48. All the lines follow exactly the same format as the first: “55 Days pass from the rising of the Arrow to the rising of the star of Eridu.” Once again, the list deals with the risings of stars; this time however, it lists periods between risings that do not always follow on each other in a direct chronological fashion. The information presented is summarised in the following table:

First Star/Constellation	Second Star/Constellation	Days between heliacal risings
Arrow	Eridu	55
Arrow (line 35)	ŠU.PA	60
ŠU.PA	Furrow	10
Furrow	Scales	20
Scales	She-Goat	30
She-Goat	Panther	30
Panther	Swallow	30
Swallow	Field	20

Field	Fish	40
Fish	Crook	35
Crook	Stars	10
Stars	Bull of Heaven	20
Bull of Heaven	True Shepherd of Anu	20
True Shepherd of Anu	Arrow (line 47)	35
Arrow	Bow	20

Table 4: Days between heliacal risings

The first order of interest in this list is that, for the first time, simple arithmetic can be performed in order to check some of the suspicions one may have regarding the information presented.

According to section II, the Arrow rises on the same date every year, 15 Du’uzu. In modern astronomy, we know this to be the case; stars appear to rise heliacally on the same date every year (with only a minor discrepancy) as the Earth returns to the same position in its orbit around the Sun, and the same section of space becomes visible. If one ignores the very first entry (Arrow to Eridu) and the very last entry (Arrow to Bow), the constellations complete a full cycle: if one stars with the Arrow in line 35, one can determine the amount of days until Arrow rises again in line 47. The sum of days is therefore:

60 + 10 + 20 + 30 + 30 + 30 + 20 + 40 + 35 + 10 + 20 + 20 + 35
…Which gives 360 days.

In modern terminology, as has been stated, a year is defined as the amount of time the Earth takes to return to the same position in its orbit around the Sun. This is known to be 365 days, not 360. In fact, since the spinning of the Earth around its own axis and its orbit around the Sun do not influence each other at all, this number is not quite that well defined – it in fact takes 365 and approximately one quarter days (Stott & Twist 1997: 80). The data, as such, has faults.

When comparing this information with section II, a few interesting things become clear. If we rearrange the heliacal risings of section II to start at Arrow, we see a huge similarity in the choices of constellations listed, except that the list in section IV is more selective.

The following 3 entries from section II stand out:
On 15th Arahsamnu the She-Goat rises
On 15th Kislimu the Panther rises
On 15th Tebetu the Swallow rises

Each of these constellations rise exactly one month after the other, and according to section IV, the difference in days between the risings of She-Goat and Panther, as well as Panther and Swallow, are in both instances exactly 30 days. Ignoring section II's entry for 5th Arahsamnu (Scorpion), the constellation preceding She-Goat, the Scales, was also supposed to rise on the 15th of the previous month (Tešritu), and sure enough the period listed by section IV between Scales and She-goat is again 30 days. As such, the dates for this section of MUL.APIN, and in fact all the sections of MUL.APIN, follow the Babylonian system of the "ideal year," when all months are 30 days long. Since there are 12 months in a year, a year is 360 days long. Even if one takes the data for other intervals where the dates each month are not identical, such as between Furrow (rising 25 Ululu) and Scales (rising 15 Tešritu), the periods (in this case listed as 20 days) are always correct for all months ending on the 30th. This concept of the "ideal year" is also known from texts involving administration, particularly when money is involved (Brown 2000: 113).

From the previous calculations, it has simply been assumed that section IV lists heliacal risings, though admittedly absolutely nothing would change if the author had intended to list first night visibility, since the periods between each would remain exactly the same.

Interestingly, section IV helps to argue in support of the hypothesis that the movement of certain dates to the 1st of the month may very well have been a matter of personal opinion, since for the most part the two sections corroborate each others' information, perhaps to the point that they one may have once originated from the same source (or perhaps, as Hunger & Pingree (1999: 65) attest, section IV was actually based on section II, and the compiler of the text included this seemingly duplicated information unknowingly). As has been stated, the dates and periods between heliacal risings for the separate lists always match, but one date has a certain discrepancy: according to section II, Crook rises on 20 Nisannu and Stars on 1 Ajjaru, but the difference listed in section IV is 10 days, not 11. This would put the rising of Stars on the 30th of Nisannu (or the 0th of Ajjaru) as suspected.

Sections II and IV together tell us much about Babylonian society in terms of its calendar, but sadly, section IV adds little to the conclusions on the scientific approach to information than was already apparent in section II, apart from reinforcing the fact that the data used was often approximated. Not only does section IV keep section II’s rounded dates, but the calculations to determine the length of the ideal year indicate that even this important facet of society (let alone scientific knowledge), supposedly based on proper astronomical observations, was an approximation.

Interestingly, a theory presented by Van der Waerden in his publication “The Thirty-Six Stars” (1949: 19), is that the author of the original text of section II drew his information from two different sources, one listing the risings on approximations of the real dates, the other of the ideal dates. In Babylonian society, it is suspected that the official new year started on 1 Nisannu, but that the astronomical new year began with the rising of the star of Sirius (in the constellation of the bow) (Van der Waerden 1949: 19). This is, in fact, mirrored by sections II and IV of MUL.APIN – one starts on 1 Nisannu, the other begins with a listing of the Bow’s rising. Van der Waerden’s theory is that the first few (4-5) entries of section II were from a list of real dates, and that when the two lists were added together the period in question would in fact (with a fair amount of calculation and assumption) form a list representing a number of days closer to a proper year. As such, he believes the author of the text to be aware of the inaccuracy of the information, and attempting to fix it. There are clues that this may be the case, or least that the first 4-5 lines of section II are taken from a different source (Van der Waerden 1949: 19). The dates for these entries are, unlike the rest, only divisible by 10 (if one takes 1 as 30). Also, section II happens to list the familiar measurements for water clocks at the colures (solstices and equinoxes) on the 15th of the respective months, but the equinox on 15 Nisannu, within the section supposed to be from a different source, is left out. Note that the colures have little or no bearing on the rest of the information from these two sections, and have thus been excluded from the more detailed analysis. Van der Waerden’s theory, however, is somewhat dated; even the stars believed to make up the various Babylonian constellations have changed since his theory was made. Also, if some dates were from the “real” calendar and others from the “ideal,” the data from section II would no longer fit the data from section IV. Even worse, it could imply that section IV was indeed just derived from section II, but using misunderstood data. Even if the theory did hold true, it would simply mean that one individual wanted to rebel against the system and correct its mistakes – the theory is based on the assumption that the ideal and real calendars were already known to be different. Scientific thought is naturally more prominent in some individuals and less prevalent in others, and perhaps this is evidence of this principle in terms of the Babylonians, but all in all, it is highly doubtful.

5.1.4 SECTION III: SIMULTANEOUS RISING AND SETTING

Though most scholars generally group sections II and IV of MUL.APIN together, the third section, ranging from lines 13 to 33 of the third column, is also connected to heliacal risings. The lines of the third section read as follows:
“The Stars rise and the Scorpion sets.”

Unlike the other two, however, no dates or periods are given, and in terms of modern interest this section is treated on its own. What is recorded, quite simply, is which constellations are disappearing over the western horizon when others are appearing in the east. The available data is tabulated as follows:

Rising	Setting
Stars	Scorpion
Scorpion	Stars
Bull of Heaven	ŠU.PA
True Shepherd of Anu	Pabilsag
Arrow, Snake, Lion	Great One, Eagle
Bow, King	She-Goat
Eridu, Raven	Panther
ŠU.PA	Field
Ninmah	Anunitu
Scales, Mad Dog, Habaşirānu	Hired Man

Scorpion, Dog	Eridu, Stars
Breast of the Scorpion, She-Goat	Old Man, True Shepherd of Anu
Pabilsag, Zababa, Standing Gods	Arrow, Bow, Crook
Panther, Eagle	Great Twins, Little Twins
Field, Great One, Stag	Lion, Snake, Habaşirānu
Fish, Old Man	Furrow, Mad Dog

Table 5: Simultaneous rising and setting

For the ancient scribe compiling MUL.APIN, inserting this section between the sections modern scholars tend to group together would have made perfect sense. The source for section II, after all, lists the dates of heliacal risings of stars. The source for section III lists which constellations would set at approximately the same time as the stars already mentioned rose. The source for section IV, interesting information but nevertheless already mentioned, was inserted afterwards, to act as a form of addendum. Placing section IV after section II would require the reader to search far back along the text in order to determine what the dates of the setting constellations were.

Of course, this is purely conjecture. The scribe could just as easily have copied over the texts given to him by a superior from a pile, and scribes in the future would not wish to alter the structure of an already existing text. If, however, the information was grouped as previously stated, this is simply more evidence of mind frames striving for logic and systemisation.

In terms of content, section III itself does not actually offer much more insight into the possible striving for scientific thought. It is, after all, simply a list of visible phenomenon – when one constellation is rising, the other can be seen setting. The practical uses of the list during the time are a complete mystery, but perhaps that in itself is an even greater indication of an approach to the scientific investigation of reality: if the list has no actual application, then the only reason for its existence is simply to be a list… a record of what was observed, jotted down out of pure interest, and nevertheless chosen to be included in an important astronomical document simply because without it the compendium would not be “complete.” Again, this is mostly conjecture – there is no actual evidence, for example, that MUL.APIN was an attempt at summarizing everything known about “astronomy” (the term itself not even existing in any Mesopotamian language without including “astrology”), but nevertheless, it does warrant thought.

Ironically, although this section of MUL.APIN was probably of least practical use during the time when MUL.APIN was a textbook of the stars, it is the section (together with Section V) which has answered the most questions with regards not only to MUL.APIN but also to Babylonian astronomy in general.

To clarify:
The modern stars listed in Section 5.1.1 [MUL.APIN Tablet I] Section I: The Star List, most certainly never appear in any ancient text. There is no Rosetta Stone of Heaven written by the Greeks to tell us which constellations in their system were equal to what stars in the Babylonian tradition – as such, for a long time, there was no way to link any specific star or constellation in the sky with any known name. It is known that it was the “Chaldeans” (the Greek name for the Babylonians) who introduced the Greeks to both the concepts of astronomy and astrology, and as such the chances are good that many of the constellations were kept, but which and to what extent are difficult to determine. Only certain constellations have minimal doubt towards their connection to both systems, via there apparent depictions of the same things, such as the Crab (Cancer), the Lion (Leo) and the Goat-Fish (Capricorn), and even then this doubt does exist – admittedly, the chances of two separate cultures both envisioning a constellation depicting a hybrid water-dwelling goat and then placing it in different parts of the sky is quite slim, but mostly even analogous constellations would first need to be proven rather than assumed.

Starting with section I of MUL.APIN, the approximate paths in the sky followed by specific stars or constellations is listed. Basic positioning is thus made known, but little else can be inferred, and while the stars of the constellations in the Path of Ea are narrowed down considerably, the enormous size of the Path of Enlil allows for little deduction. Section II provides substantially more data – it provides the chronological order of the risings of certain constellations, as well as the approximate dates on which they rise heliacally. Together with the information from Section I, a general idea can be constructed of at least where each constellation appeared in the Babylonian sky with respect to the others.

What occurs in Section III (and Section V, to be discussed shortly), is that the previously listed data is given important constraints: not only does one know that the first star of the constellation of She-Goat rises on (approximately) 15 Arahsamnu, one also knows that the last star of the constellation disappears over the horizon when the Bow rises on about 5 Abu. Periods of visibility can be used to better approximate a star or constellation's declination – low periods of visibility in the sky mean that the stars rise and set in positions closer to the southern point of the horizon. Not only are the declinations further defined, but the relations of the different constellations become even more sturdily interlinked – a chain is formed.

Scholars, as such, have been able to use Section III's data to its fullest in creating basic lists of Babylonian stars. The analogous stars listed in section I were calculated by Reiner and Pingree; the most recent (and, by consensus, decently accurate) attempt at creating a list.

The modern calculations have little to do with the ancient thought processes, however, so will be largely omitted. It should be noted, however, that in most attempts at identification the analogous Greek constellations (such as the Great Twins = Gemini, The Scorpion = Scorpio) are often used as a starting point, and then once more data is acquired, are investigated from a backwards perspective to see if they still fit in the system. Another interesting technique, directly linked to section III, is that once the general declination of a constellation is known, the difference in its period of rising and setting can help to determine that constellation's constraints – its size. Heliacal risings, after all, rely on the appearance of the first star of the constellation, while the setting implies the disappearance of the last star. Once the declination for a star is known, the amount of time it takes to set is also known, and the difference in time between this setting of the first star and the setting of the last star can be used to determine the amount of sky the entire constellation takes up.

Reiner and Pingree’s work not only helps to define the constellations, but amazingly the nature of the data in section III also allowed for an approximate dating of the text. The reason for this is as follows:

Just as the Earth revolves around the Sun, the Sun revolves around the centre of the Milky Way galaxy. As far as life on Earth goes, this has very little impact; there is no creation of time-based phenomenon (seasons and the year) such as with the Earth’s orbit around the Sun. The Sun’s orbit around the centre of the galaxy is, after all, extremely slow.

As previously stated: when the Earth returns to its original position in its orbit around the Sun, after a single year has passed, the same stars should appear in the sky again at the same time. The same section of the sky, in other words, should be visible again. The fact of the matter is that by the time the Earth returns to its same position, the Sun itself has moved (actually, the entire universe has shifted slightly – everything orbits around something else eventually) such that the Astronomical year in fact differs from the Solar year – it is about 20 minutes shorter (Horowitz 1998: 153). This variation in the lengths of the two types of years brings about a very important consequence: during the date of the compilation of MUL.APIN section II, the Bow was said to rise on the summer solstice, the longest day of the year. The date of its rising changes by one day every 74 years, so if one knows which star to identify, and calculate back from modern position to work out when this statement would have been true, a date can be determined. Sadly, since the data of MUL.APIN comprises of infuriating approximations, the process becomes longer.

To make matters more complex, not all portions of the sky are visible from the same positions on the Earth – everyone is viewing the sky from a different angle. The view of the stars from Babylon would not be identical to the view from Assyria. As such, calculating when the bow rose for Babylon and when it rose for Assyria could lead to (albeit only slightly) different dates. Not only do the positions of stars seem to vary from place to place, but because the Earth’s axis, which as has been mentioned is slanted, actually wobbles (its slant changes slightly over the course of many thousands of years) declinations even for one location actually do change.

However: changes in declination lead to alterations in the times of constellations' rising and setting. As such, simultaneous rising and setting actually becomes an even more valuable constraint to the rest of the data – once the stars of the constellations of, for example, the Scales and the Hired Man are known, the use of simultaneous rising and setting, which (due to all the complex movements already mentioned) are only correct for very specific times and viewing angles, finally allow for data to be inserted into theoretical models which can help pinpoint, quite accurately, the origins of the rest of the data. Reiner and Pingree's conclusions are that the data from MUL.APIN for sections I, II, III and VI, are all mostly correct for a date of 1000 BCE (Reiner & Pingree 1981). The place of observation, amazingly enough, does not best fit Babylon, but rather of an area along the 36°N Meridian – in line with the city of Nineveh.

5.2.5 SECTION V: SIDEREAL DAY

Following the simultaneous risings and settings, the fifth section of MUL.APIN is only 2 lines long (column 3, lines 49-50). The section reads:

iii.49. The stars enter into the night in the morning 1 UŠ each day.
iii.50. The stars come out into the day in the evening 1 UŠ each day.

The two lines hint, obviously, at progression, since something is happening each day. Entering into the night in the morning implies that something is occurring at a later stage each day – it starts happening in the morning, but gradually enters into the night. This continues during the night, now edging towards day. This is a phenomenon already investigated: the varying rising times of the stars. The stars appear to rise earlier and earlier each day, until eventually they become visible in the evening.

As the Earth orbits around the Sun, it spins around on its own axis. This, as has been stated, causes night and day. One day, however, is not exactly equal to one spin of the Earth's axis, but rather the period from when a point of the Earth's surface is directly facing the Sun the next time it is directly facing the Sun; the time from noon to noon, 24 hours. Though the phenomenon is caused by the spinning of the Earth's axis, it in fact takes a bit longer than a single spin to cover a full 24 hours, since the Earth continually moves relative to the Sun. Regions on the Earth's surface, however, "point" to the exact same section of space every time after it has completed one axis revolution, a period slightly shorter than the Solar day. As such, with respect to daylight, stars appear to rise earlier and earlier each day.

The term to define when a section of the Earth is facing the same direction of space is known as a "sidereal day" – a length of time equal to its spin around its own axis. A sidereal day is calculated to be 23 hours and 56 minutes long, 4 minutes shorter than a Solar day, and as such, the stars should rise 4 minutes earlier each day.

Looking at the two lines from MUL.APIN, it is stated that the stars grow closer to the night from the morning by 1 UŠ a day – in other words, they rise 1 UŠ earlier. UŠ is known from multiple other sources to be a Babylonian unit of time, which is simply confirmed again here. It subscribes to the typical base 60 system of most Babylonian numerical units, in that it is divided into 60 GAR. Furthermore, 360 UŠ are known to make up one day – so one UŠ is equivalent to, amazingly, 4 minutes of modern time (Van der Waerden 1951: 22).

There is no indication as to how this value was calculated. As such, no conclusions can be drawn about methodology with regards to scientific approaches. In fact, it should be assumed that this value was obtained purely through numerous observations and comparisons. All it tells us, then, is that someone, sometime, had the dedication and drive to determine this.

5.2.6 SECTION VI: ZIQPU STARS

Section VI, which starts from the very first line of the fourth column, and spanning 30 lines, in fact consists out of two different lists (originating from two different original sources). However, the extremely similar nature of the contents promotes that they be discussed as a single unit, and truthfully, scholars such as Hunger & Pingree have done the same.

Unlike the other sections, both lists of section VI start with lines which could be termed "introductions". The introduction to the first list reads:

iv.1. The *ziqpu* stars which stand in the path of Enlil in the middle of the sky
iv.2. opposite the breast of the observer of the sky, and
iv.3. by means of which he observes the rising and setting of the stars at night.

Lines 7 to 9, appearing after the first list, repeat this information. Rather than an introduction to the following section, these lines are possibly a “conclusion”, confirming what has been said – only a few words in the beginning of the sentence have been changed.

iv.7. All these are the *ziqpu* stars in the path of the stars of Enlil which stand in the middle of the sky
iv.8. opposite your breast, and by means of which you observe
iv.9. the risings and settings of the stars at night.

The second list, as such, most likely starts with the following lines, which also form an introduction to the data that follows:

iv.10. If you observe the *ziqpu*, you stand
iv.11. in the morning before sunrise, West to your right,
iv.12. East to your left, your face directed towards South.

From these lines, it is noticeable that a completely new concept is being introduced, that of a special type of star/constellation known as a *ziqpu* star. Fortunately, the information gleaned from the two introductory sections is enough to discover exactly what this term entails.

To observe a *ziqpu* star, a person should be facing south. This is a logical first step in any astronomical observation since, as has been explained in Section 4.2: Astrolabes, the majority of the objects in the night sky of the northern hemisphere appear in the southern part of the sky. Since the *ziqpu* stars should be observed in the morning before sunrise, one can suspect that they are somehow connected to the heliacal risings of stars. *Ziqpu* stars, however, are claimed to be visible opposite the breast of the observer – as such, when viewed the *ziqpu* stars will be due south in the sky. The most defining feature, of course, is that they are all stars of the Path of Enlil. When facing south, not much of the Path of Enlil can be observed – although the largest path, containing the entire northern sky, only a very faint sliver of it is visible when facing south. In fact, the only part of the path really visible, which can still be claimed to be part of the southern sky, is that which passes almost directly overhead. This is not a problem, however, since this is exactly what the final condition implies: *ziqpu* stars appear in the middle of the sky, which can thus be implied to mean directly above the observer's head. *Ziqpu* stars, by definition, are thus stars or constellations which will, at some stage, pass through the very centre of the sky.

The first source of section VI is a very basic list of 14 such *ziqpu* stars, with no additional information presented. The *ziqpu* stars listed are as follows:

ŠU.PA
Dignity
Standing Gods
Dog
She-Goat
Panther
Stag
Old Man
Crook
Great Twins
Crab
Lion
Eru (Frond)
Abundant One

The second list is somewhat more elaborate. Not only does it list *ziqpu* stars, it also lists constellations which rise at the same time as the current star is fulfilling the role of the *ziqpu*. This seems to have been the actual purpose in the identifications of *ziqpu* stars – the introduction to the first list clearly states that they are the means by which a person observes the rising (and setting) of the other stars. According to Olmstead (1938: 116), a physical instrument known as a *ziqpu* (a type of pole) was used by

Tukulti-Urta I in the twelfth century BCE while rebuilding the Ashur palace. As such, the stars most likely obtained their name from this instrument, as both would entail the use of a vertical line to assist in making other observations. Ironically, while the first lists states this function, it provides no data, while the second list, which provides the data, does not explain why.

The format of the second list is as follows:

iv.13. On the 20th of Nisannu the shoulder of the panther stands in the middle of the sky,
iv.14. opposite your breast, and the Crook rises.

The data can be tabulated as follows:

Date	*Ziqpu*	Rising Constellation
20 Nisannu	Shoulder of the Panther	Crook
1 Ajjaru	Breast of the Panther	Stars
20 Ajjaru	Knee of the Panther	Jaw of the Bull
10 Simanu	Heel of the Panther	True Shepherd of Anu
15 Du'uzu	Bright star of the Old Man	Arrow
15 Abu	Dusky stars of the Old Man	Bow
15 Ululu	Great Twins	ŠU.PA, Eridu
15 Tešritu	Lion	Scales
15 Arahsamnu	Eru (Frond)	She-Goat
15 Kislimu	ŠU.PA	Panther
15 Tebetu	Standing Gods	Swallow
15 Šabatu	Dog	Field
15 Addaru	She-Goat	Fish

Table 6: *Ziqpu* stars

A quick glance at the dates in the second list immediately reminds one of Section II – they are rounded off. The chances are very good that the original source for the rising constellation was the same as that used for Section II. Notably, the dates of the rising for Bow and Field have been altered – they now occur on the 15th of their respective months (both rise on the 5th in Section II). Hunger & Pingree (1999: 70) assume that this was arbitrary; the dates were changed simply to fit the rest of the scheme, as no risings for the 15th occur for these respective months in Section II. The dates for the first four entries are not rounded to the 15th of the month; however, this may simply have been due to the fact that the data would have become simply too inaccurate. The *ziqpu* stars for the first four entries, after all, are single stars, not constellations. In the first list, Panther is listed as a *ziqpu* star, but the constellation of Panther is extremely large. The second list, which can be assumed was written later, divides it up into smaller parts, making use of its prominent stars rather than the constellation as a whole. As single stars, the observations would have stricter limitations, and as such the author may have decided to keep the dates as they were, with the deviations at a minimum. Of course, since the dates were rounded in the first place, and the Old Man, also broken up, has its two prominent stars rising on the 15th, means that this has to remain an enigma. Interesting to note, however, is that the unchanged dates are from the part of section II's list which Van der Waerden (1949: 19) believes to have had a different original source.

In term of scientific thought and approaches, the second list thus has negative connotations. The scribe of this list, in order to conform to a scheme, seems to have been prepared to arbitrarily alter known data to suite his own needs. The data, inaccurate to start with, has been made even more so. It should be mentioned that this is not something which does not occur in the modern scientific community – many scientists are guilty of "tweaking" data to suits their own needs – but it goes against what can be defined as the drive behind the scientific mind, the search for truth.

Comparing the two lists, it is noticeable that several constellations from the first do not make it into the second. These are:
The Stag, the Crook, the Crab, the Abundant One and Dignity.

As it turns out, this exclusion is not completely arbitrary. According to the theory of Hunger & Pingree (1999: 69), these *ziqpu* stars were cut because later scribes felt that they did not properly fit the criteria – in other words, they should never have been included in the first list in the first place.

Before proceeding, a few aspects on the modern system of locating stars via declination need to be expanded upon. As mentioned in Section 4.2: The Astrolabes, when determining the position of the celestial equator, it was explained that the point above the viewers head is given a value of 90. The celestial equator is found in the sky by subtracting the observer's latitude from this value. Since Hunger and Pingree (1999: 66) believe this to have been from 36°N, this new point is designated the 0° line. Working back up to the point directly above the observer's head, which is also where the *ziqpu* stars appear, simply means to go up those 36 points again. Since these points are intersected by the equivalent lines of declination, the *ziqpu* stars for 36°N should, in turn, all thus have a declination of close to +36°.

By calculating the right ascensions of the stars mentioned in the first list, Hunger and Pingree came up with the following data:

Constellation	*ziqpu* Star	Declination
ŠU.PA	α Boötes	+35;2°
Dignity	α Coronae borealis	+39;50°
Standing Gods	β Herculis	+31;47°
Dog	θ Herculis	+41;11°
She-Goat	α Lyrae	+39;47°
Panther	α Cygni	+37;33°
Stag	γ Andromedae	+26;7°
Old Man	α Persei	+35;16°
Crook	α Aurigae	+36;12°
Great Twins	α Geminorum	+31;43°
Crab	ε Cancri	+24;36°
Lion	ε Leonis	+32;57°
Frond	γ Comae Berenices	+44;17°
Abundant One	β Comae Berenices	+43°

Table 7 = List Va (Hunger & Pingree 1999: 69)

Since declinations of entire constellations are difficult to determine, as *ziqpu* stars, Hunger and Pingree use bright and prominent stars from the constellations in question. There is, of course absolutely no evidence that the Babylonians looked for specific stars within the constellations – the *ziqpu* stars, unless otherwise stated, should be assumed to be the constellations in their entirety. The calculation of the declinations for these different stars, taken for 1000 BCE at 36°N, nevertheless does give an indication of the declinations of the constellations in general.

The constellations which are no longer included in the second list have declinations as follows:

The Stag	+26;7°
The Crook	+36;12°
The Crab	+24;36°
The Abundant One	+43°
Dignity	+39;50°

Considering that ideal *ziqpu* stars should have declinations as close to +36° as possible, the Crab and Stag are believed to have been cut from later lists because they were actually too low in the sky. Similarly, the Abundant One is also too low in the sky, though in the opposite direction (to the north). Ideally, the Frond, which has even higher declination than the Abundant One, should have been cut as well, but was likely kept since it fit well with the date criteria of the second list.

Dignity was likely excluded from the second list because it was unnecessary within the required context, but the exclusion of the Crook is apparently an error. According to Hunger and Pingree's (1999: 70) calculations for the second list, many of the entries are simply wrong. The Crook would have been a better match for the entry of 5 Abu, the reason for the selection of the Dusky Stars of the Old Man is unknown. It also seems that the scribe of the original text, while copying from other sources, read them incorrectly – the true *ziqpu* star for Arahsamnu is missing, and the star for the following month, Eru, is inserted in its place. This error is repeated until the end of the section, ending with the She-Goat on 15 Addaru which should be the *ziqpu* star for 1 Nisannu, a date not mentioned in the second list (Hunger & Pingree 1999: 70).

The Babylonians in terms of the second list can, on the one hand, be seen as scientifically-minded. To scientists, concepts and theories require constant revision, with disproven and irrelevant hypotheses discarded. This is exactly what the scribe of the second list has attempted to do – to create a revision of existing knowledge, where outdated concepts are removed (constellations too far from the centre of the sky removed from the list) and new ones added (the splitting of Panther into sections).

The scribe of this section is also a very different type of scholar, clearly focusing his time on the studying of secondary texts (since his knowledge seems to be based solely on what he is reading, hence the numerous mistakes). His apparent drive to revise outdated data is countered, however, by the fact that his errors are never corrected – after the first compilation of MUL.APIN, the sections do not change. Despite the fact that many of the scribes possibly knew the information was incorrect, it was never removed or changed in the later copies. It appears, then, that customs, traditions and established institutions preventing the alteration of the text were considered more important than actual scientific progress.

5.1.7 SECTION VII: THE ECLIPTIC

The final section of the first tablet is nine lines long, ranging from lines 31 to 39 of the fourth column. As with section VI, a few introductory words are given to explain the list that follows:

iv.31. The gods who stand in the path of the Moon, through whose regions the Moon in the course of a month
iv.32. passes and whom he touches:

It concludes with the same lines, but adds “All these are” to the beginning of the first sentence.
The list is as follows:

Stars
Bull of Heaven
True Shepherd of Anu
Old Man
Crook
Great Twins
Crab
Lion
Furrow
Scales

Scorpion
Pabilsag
Goat-Fish
Great One
Tails
Swallow
Anunitu
Hired Man

There is not much to clarify with regards to this list – the introduction is really self explanatory. During its path through the sky, the Moon will, at some point, pass in front of the listed constellations.

Notably, as shall be mentioned in the following section, since the Sun and Moon travel across the same path of the sky, the Sun also passes through these constellations. The rising of the Sun within specific constellations (thus passing through them) is the definition of the Greek Zodiac. This list is, to be exact, a list of the constellations on the ecliptic, discussed in more detail in the following section.

This list would have been extremely useful to the early scholars in the identification of the Babylonian constellations, particularly since it confirms that many of the suspected analogous constellations indeed followed the same path – Scales, Crab, Scorpion, Goat-Fish, Lion, etc., and could thereby be assumed to be constituted of roughly the same stars.

This list does not, unfortunately, add much to the investigation of scientific thought. As with many of the other lists, it hints at a desire for systematic recording of information, but the lack of additional data (dates) leaves this text feeling incomplete. It is simply a record of basic observation with no practical application, not complete enough to be considered to have been written by someone with a truly inquisitive mind.

5.2 TABLET II

5.2.1 SECTION VIII: THE ECLIPTIC CONTINUED - PLANETS

The second tablet of MUL.APIN begins with the line:

i.1. The Sun travels the same path the Moon travels

In the next few lines, this information is repeated, each time replacing the subject with a different "star"
Jupiter
Venus
Mars
Mercury (whose name is Ninurta)
Saturn

These are then followed by a short conclusion:
i.7. Together six gods who have the same positions, who touch the stars of the sky and
i.8. keep changing their positions.

Apart from the first god, the Sun, the others are of a special type of star. In section I of tablet I, each time one of these particular stars is introduced, it is added that it "keeps changing its position and crosses the sky." Unlike the other stars, the positions of these five do not remain fixed. They are, of course, the five planets of the solar system that can be seen from the surface of the Earth, the rest being invisible without the aid of instruments. In other texts, stars are often referred to (metaphorically) as tame sheep, while the planets are *bibbu,* wild goats.

This section is a logical progression from Tablet I Section VII: The Ecliptic (Section 5.1.7), which introduces the path of the Moon. Here it is just expanded upon by explaining that the Sun and the planets, the only stars to change their positions with respect to the rest, follow the same path – in other words, their progression through the sky is similar. Not only that, but it is emphasized that they have the same "positions" – likely indicating that they rise and set on the same points of the horizon (Hunger & Pingree 1999: 73).

In the astronomical sense, this is perfectly true. The Moon's orbital path around the Earth is approximately level with the Earth's orbital path around the Sun, which, when applied to the illusion of these bodies crossing the sky, leads to them following the same path. The orbital paths of the other planets around the Sun are also approximately level with the Earth's orbital path, and so for them it is the same. When describing the path of the Sun, Moon and planets across the sky, it is thus generally stated that they follow the ecliptic – the term for the plane of the Earth's orbit.

The fact that the orbit of the various bodies in the solar system is basically level can be explained by how it is believed to have formed – from a cloud of gases and solid particles. Gravity pulls objects together, and so the centre of this cloud condensed to form what is now the Sun. The Sun's gravitational pull caused the rest of the particles to start spinning around it, and flatten into a disc. Any further explanation requires delving into the nature of the universe and requires complex explanations requiring an understanding of the nature of gravity and different dimensions (using the often joked about but nevertheless relevant "rubber sheet" theory) so will be avoided – however, to summarize, the planets and moons were formed by new centres of gravity attracting other matter within this already flattened cloud.

Of course, why the Moon should be chosen to be the representative of the ecliptic in MUL.APIN is never clarified. The texts itself offers no hints. It can only be surmised that it was chosen because it is the most clearly visible and definable of the astronomical bodies. While the Sun and Moon can be observed at the same time in order to make comparisons, and similarly the Moon and the planets can be observed at the same time, the invisibility of the planets in daylight means that it is difficult to relate them to the Sun. The Moon, being the most clearly definable in its relation to the rest, is therefore the representative of the path.

This passage indicates a willingness of the mind not to restrain itself to only a single system – while Section I groups the planets together with the other stars due to their similar appearance, this section group them together with the Moon and Sun due to similar movements. The desire to interrelate data is a factor of scientific approach, but then again, the movements of the planets are an indisputable observable fact, so perhaps this assumption is unfounded.

5.2.2 SECTION XI: PLANETARY VISIBILITY

The structure of the second tablet of MUL.APIN is nowhere nearly as logical as the first, at least to the modern reader. As such, the various sections of the second tablet will not necessarily be investigated in order. Keeping to the investigation of the planets, the next section to be investigated is therefore that which stretches from line 44 to line 67 of the first column.

This section of MUL.APIN is dedicated first to recording the amount of time the various planets are not visible in the sky, and secondly to the amount of time they remain visible in the sky. Together with their respective periods of visibility, a short description of the planet is given.

It should be mentioned that this is the first section of MUL.APIN to list variables – in some cases, several possibilities are listed. It is possible that the text from which this section was copied into MUL.APIN was derived from multiple sources. The data is presented here grouped in terms of the various planets, listed in descending order according to their distance from the Sun (and increasing complexity of data) rather than the order in which they appear in the text:

Saturn:

Appearance: Red or white

Saturn becomes visible in the East, and stands in the sky for
1 year
It disappears in West, and remains invisible for
20 days

Jupiter:

Appearance: Not given

Jupiter becomes visible in the East, and stands in the sky for
1 year
It disappears in West, and remains invisible for
20 days or 1 month

Mars:

Appearance: Bright red, or [missing] and small

Mars becomes visible in the East, and stands in the sky for
1 year 6 months, 1 year 10 months or 2 years
It disappears in the West, and remains invisible for
2 months, 3 months and 10 days or 6 months

Venus:

Venus appears in either the East or the West, and stands in the sky for
9 months.

It may disappear in the East, after which time it will be invisible for
1 month, 1 month 15 days or 2 months
and then become visible again in the West.

If it disappears in the West, it will be invisible for
0 (literally, it appears again the same evening), 3, 7 or 14 days
and then become visible again in the East.

Mercury:

Appearance: Red and bright or yellow and dark

Mercury becomes visible in either the East of West, remains in the sky for
7, 14 or 21 days, 1 month or 1 month 15 days,

After it disappears it will be invisible for the same amount of time that it was previously visible, and may reappear in either the East or the West.

There is another entry for Mercury, which simply states
"Mercury becomes visible in either the East or West and disappears within a month" – its wording and style is most similar to the style used for the first entries (the disappearances), but it is the very last line of the section. This is, perhaps, evidence that two sources were used, and that the scribe forgot to include this information in the beginning.

The Babylonian drive to observe and record led them, in this instance, to discover that the planets moved at different speeds throughout the sky. This is caused by the fact that the further planets are away from the Sun, the longer it takes them to complete a single orbit. Unlike fixed stars, the planets keep moving, so after a year the planets will not have returned to the same relative positions. The time taken for this to actually occur is known as a *synodic period*, the time it takes for the Sun, Earth and planet to form a straight line. When calculated correctly, this should be equal to a planet's period of visibility plus its period of invisibility. Venus and Mercury, however, will disappear twice within a synodic period, caused by the fact that they are closer to the Sun than the Earth with faster orbital periods, making their visibility in the dark somewhat erratic. When they are between the Earth and the Sun, as well as when they are on the opposite side of the Sun, they are not visible.

The synodic periods for the different planets (Hunger & Pingree 1999: 74-75):

Saturn:	378 days
Jupiter:	398 days
Mars:	780 days
Venus:	584 days
Mercury:	116 days

The observations for Jupiter and Saturn, which are by far the easiest, are quite close. For the rest, however, the data is a mess. As mentioned by Hunger and Pingree, there are combinations of values under the different planets which do give values close to what should be expected (Hunger & Pingree 1999: 74), but there is little or no structure to the information. For Mars, to obtain a value close to 780 days, the longest listed visibility can be added to the shortest listed invisibility, but the opposite (shortest visibility with longest invisibility) gives a lower, different value, and the intermediate values are simply impossible.

As for Venus – the values presented in this source were most likely derived from the *Venus Tablet of Ammişaduqa*, the 64th tablet of *Enuma Anu Enlil*, discussed in Section 4.2: Enuma Anu Enlil (admittedly even in this tablet the periods of visibility hardly ever reach 9 months). Astronomical scribes, after all, were all knows as the *tupsar Enuma Anu Enlil*, a factor which shall be investigated in Section 7. These values follow tradition, but that does not mean that they are correct. In general, a period of visibility of 90 days for Venus is too long (Hunger & Pingree 1999: 74).

For Mercury, the observer clearly gave up on attempting to properly classify the (truthfully daunting) data. Instead of ordering the values of the periods in such a way as to allow a system to be followed, the periods are simply listed in values of increasing numbers of days. Then again, the rest of the section follows the same structure, so perhaps the scribe who copied this text misinterpreted what he was reading.

This section is, without a doubt, an astronomical text – it exists purely to state the obtained values, and does not attempt to interpret them (such as *Enuma Anu Enlil* does with its similar data). However, with regards to the Babylonian approach to scientific method, the text is wanting. Considering the fact that the lines were likely copied word for word from the initial separate sources, a correlation of the data cannot rightly be expected, but it should then also be remembered that these two sources were inserted into MUL.APIN directly after one another for a reason. It is a mystery why other scribes did not attempt to create a more complete version with matching data for inclusion into this important compendium.

Then again, in terms of logic and the thoroughness of investigation, it is sad to say that there is no evidence that the Babylonians realised that the periods of visibility added to the periods of visibility would give a constant value in each instance. As such, the scribes would not even see the need to match observations. Finally, the data of this section is simply inaccurate. Somewhere along the line, the scientific approach to the data was skewed and lost.

5.2.3 SECTION IX: INTERCALATION

Returning back to lines 9-24, the text reads as follows:

i.9. On the 15th of Du'uzu the Arrow becomes visible.
i.10. 4 Minas is a daytime watch, 2 minas is a night-time watch.
i.11. The Sun which rose towards the North with the head of the Lion
i.12. turns and keeps moving down towards the South at a rate of 40 NINDA per day.
i.13. The days become shorter, the nights longer.

i.14. On the 15th of Tešritu the Sun rises in the Scales in the East,
i.15. and the Moon stands in front of the Stars behind the hired Man; 3 minas is a daytime watch, 3 minas is a night-time watch

i.16. On the 15th of Tebetu, the Arrow becomes visible in the evening. 2 Minas is a daytime watch, 4 minas is a night-time watch.
i.17. The Sun which rose towards the South with the head of the Great One turns and
i.18. keeps coming up towards the North at a rate of 40 NINDA per day. The days become longer, the nights become shorter.

i.19. On the 15th of Nisannu the Moon stands in the evening in
i.20. the Scales in the East, and the Sun in the West in front of the Stars behind
i.21. the Hired Man.

i.22. On the 15th of Nisannu, on the 15th of Du'uzu, on the 15th of Tešritu, on the 15th of Tebetu,
i.23. you observe the risings of the Sun, the visibility time of the Moon, the appearances of the Arrow,
i.24. and you will find how many days are in excess.

Much of this information has already been presented in MUL.APIN. This is a list, after all, of the conditions surrounding the colures (equinoxes and solstices). This is evidenced by the inclusion of the data from the water clocks, which has been explained in Section 4.2: The Astrolabes.

Additional information is given here in terms of the progression of the Sun with respect to time – it is said to move at a rate of 40 NINDA per day. 60 Ninda equal 1 shekel, 60 shekels equal 1 mina. This is simply additional information, since the rate can be calculated by dividing a 1 mina change in water by the amount of days it takes to change, 90. Nevertheless, by clearly stating this information, we can confirm that the rate of water exiting a water clock was supposed to be constant (which would mostly counter Neugebauer's (1947:38) weight theory).

Apart from the water clock data, a few astronomical conditions are also set for the dates of the colures – the Sun and Moon are expected to rise and culminate with specific constellations on the specific dates. All this sees superfluous, as most if the information can be found in other sources, but the very last line of the section hints to exactly why these specific dates and observations are important:
"You will find how many days are in excess".

This section, in other words, does not exist to list the phenomenon, but rather instructs others to observe the sky on the given dates, and find out if the sky is different to what is expected. As such, it is the first mention in MUL.APIN of the system for which the astrolabes were originally created – the system of intercalation. Section IX cannot be stated to be a purely scientific text – the purpose is more important than simply the data. However, the nature of the information means it is still astronomical, and as such saw its inclusion into MUL.APIN. There are little indications, however, of any inclination towards scientific approaches.

5.2.4 SECTION XIV: INTERCALATION CONTINUED

There is a considerable leap in the text between the first mention of intercalation in section IX and its next appearance in the second column. Clear progression of information, however, demands that this second intercalation scheme be investigated next.

This section starts on (what is calculated to be) the eighth line of the second column, but it should be noted that from this point the numbering of translation used differs from the original tablets. The reason for this is simply convention: As was previously explained, line numbers are usually based on the most complete examples of tablets discovered. For Tablet II, these line numbers are based on VAT 9412+11279, yet for this tablet, what is believed to be the first 15 lines of the second column are missing. Tablets which do preserve this information do not follow the regular format, and as such, the consensus is to rather restart the column numbering from the first existent line in VAT9412+11279. Section XIV, as such, starts with what the translators' term "Gap A, line 8" (Hunger & Pingree 1989: 88-89, 131). It continues until the official 20th line of the second column.

The first two lines stated are the most unique, reading:

A.8. If, on the 1st of Nisannu, the Stars and Moon are in conjunction, this year is normal.

A.9. If on the 3rd of Nisannu the Stars and Moon are in conjunction, this year is a leap year.

The lines that follow them are all of a similar format, but usually focus on heliacal risings:

ii.5. If the Fish and the Old Man become visible on the 15th of Addaru, this year is normal.

ii.6. If the Fish and the Old Man become visible on the 15th of Nisannu, this year is a leap year.

The majority of the information, like lines 5-6, simply state: if something should be observed on the 15th of the month, but is instead observed on the 15th of the next month, the year is a leap year.

Condition	Ideal Date	Leap Year
Stars and Moon in conjunction	1 Nisannu	3 Nisannu
Arrow rises	15 Du'uzu	15 Abu
Sun and Moon in conjunction	15 Arahsamnu	15 Kislimu
Arrow visible at night	15 Tebetu	15 Šabatu
Fish and Old Man rise	15 Addaru	15 Nisannu

Table 8: Intercalation

The Babylonians, despite keeping with their conventional system of assigning 12 lunar months to a year, were, as has been mentioned, were certainly aware that the system was not correct. When months were too far off it caused problems for farmers, and (most likely directly connected to this fact) the late rising of stars were quoted as being unlucky (Horowitz 1998: 164). Here, the system of correction is described in minute detail. The calendar would be fixed by introducing an extra month into the year – an intercalary month – which is mentioned several times in the following lines of this section. This month was not a new month, but rather a repetition of another month in the calendar. Three such possible months are listed in MUL.APIN:

ii.18. An intercalary Nisannu belongs to the reign of Šulgi,
ii.19. an intercalary Addaru belongs to the reign of Amurru,
ii.20. an intercalary Ululu belongs to the reign of the Kassites.

These months obviously have historical significance, but sadly, this is not explained. Most of the time, when the decision was made to intercalate, the month to be repeated was the month in which the decision was made, and would follow it directly.

Line 12, appearing before these listing, states a fact that can be derived from the earlier texts, but here is stated openly:

ii.12. 10 additional days in 12 months is the amount for one year.

The Babylonians, as such, were aware that the year they were using was exactly 10 days too short. The lines that follow are made up of commands. What they describe, in short, is that if you discover a discrepancy of 10 days in the phenomena, you should announce a leap year for the third year from then. Basically, the author of the text is saying not to wait until the last minute, leap years can be declared in advance.

Astronomical data from these two sections is probably at its most practical, just as it was for the astrolabes – the fixing of the calendar would have been vital to the proper functioning of society. Yet these sections also provide evidence of a society bogged down by unwillingness to reform established institutions. A more scientific and accurate approach to the length of the year would have prevented these problems from occurring in the first place. Practically, though, it must be admitted that basing dates of the month on the lunar cycle was simple enough for the uneducated populace to apply, while more accurate stellar observations would have only been possible for the scribes. Practicality has to take preference over scientific accuracy.

5.2.5 SECTION XII: THE COMPASS

The final lines of the first column of tablet II present an interesting connection to the most important aspect of practical modern astronomy of the last few centuries – compass points. During the day, it is relatively easy to find ones general bearing with respect to the points of the compass. The Sun, after all, rises in the East and sets in the West – observation around these times helps one to identify directions. Of course, on a long trip, particularly at sea, heading *vaguely* north can land a person or ship in a lot of trouble. The stars, per say, always have been better indicators. Constellations tend to stick to their declinations at least, and as such bearings can be calculated very precisely with the right reference material. For the casual observer of the sky, on the other hand, even without complex reference books, basic compass points can still be determined at night.

The key to basic observation is the existence of circumpolar stars or constellations. These are constellations which appear to never actually rise or set (they still circle around a fixed point, just never disappear beneath the horizon), and are found in the part of the sky equivalent to the hemisphere of the viewer (a circumpolar star in the northern hemisphere is in the northern sky). In modern astronomy, the best indicator for North, in the northern hemisphere, is known as the Pole Star. In the southern hemisphere, there is no true "pole star" – the exact southernmost part of the sky is void of special stars – but the Southern Cross constellation always points to the south.

Of course, these constellations have shifted since Babylonian times, but MUL.APIN provides its own list of constellations that served a similar purpose.

i.68. If you are to observe the direction of the winds: the Wagon lies across where the North wind rises,
i.69. The Fish lies across where the South wind rises, the Scorpion lies across where the West wind rises,
i.70. the Old Man and the Stars stand where the East wind rises.
i.71. On the day of your observation the stars will indicate to you which wind blows.

The list insists on naming winds, but it can be surmised that this source was inserted into MUL.APIN for its greater application of determining the compass points in general. Even if this was not the intention, it did still fulfil this purpose.

Looking at the text, The Wagon (the constellation for North) is indeed a circumpolar star which, at the time, had a small rotation. As a pole star (or in this case, constellation) it would be accurate enough to serve as a general indicator for North. As the star for South, the Fish was probably about as good as any of the various constellations in the Path of Ea. It would, however, be invisible at times, and even when visible it would only indicate a general southern direction. As for the constellations for East and West, these would only be accurate for certain times of the year. Constellations rising on the Eastern and Western horizons make large arcs across the sky, and then set in the opposite direction. One can only hope that the date for the information has been omitted; if not, the scribe for this source was extremely ignorant. Scorpion, the constellation for West, is actually a constellation of the Path of Ea (one would expect the Western constellation to be from the Path of Anu) so will, at best, be in the south-western segment of the sky just before the time of its setting. The best way to explain this is to emulate Koch (1995) in assuming that the Scales (referred to in section I as “the horn of the Scorpion”) is what is actually being referred to.

This section of MUL.APIN is an attempt at a scientific text with practical applications. Sadly for a person attempting to apply this information without knowing any better, it could get that individual hopelessly lost. As the text progresses, it becomes evidently more clear that the scribe in charge of compiling the different texts of MUL.APIN did not, himself, have much astronomical knowledge, or perhaps was too worried about breaking tradition to allow him to ignore such an inaccurate text. The scribes of the original sources for most of the preceding sections would have been able to identify this information as false.

5.2.6 SECTIONS XIII - PATHS

The portion of MUL.APIN dealing with the Paths of Enlil, Anu and Ea has already been dealt with in Section 4.2: The Astrolabes, and thus shall not be repeated. This would have appeared in the first seven lines of Gap A.

5.2.7 SECTION XV – SHADOWS

It should be noted, before continuing with the discussion of section XV, that this section has only a very shallow root in astronomy. It deals with the lengths of shadows during certain times of day for the colures of the year. However, while not an astronomical text per se, it is an exercise in scientific data collection. The data is presented in a straightforward, unintroduced fashion, beginning with line 22 of column 2.

ii.21. On the 15th of Nisannu, 3 minas is a daytime watch, 3 minas is a night-time watch.
ii.22. 1 cubit of shadow, 2 and a half bēru of daytime
ii.23. 2 cubits of shadow, 1 bēru 7 UŠ 30 NINDA daytime
ii.24. 3 cubits shadow, two-thirds bēru 5 UŠ daytime

A complete table of the data can be presented as follows. Note that 1 *mina* of water in a water clock measures 2 *bēru* of time – 1 *bēru* is 120 minutes long. Unlike the regular base 60 system employed by most other Babylonian mathematical units, there are only 30 UŠ in one *bēru*, as such, a personal notation is used in the following table. The base-60 notation is kept for UŠ;NINDA.

15 Nisannu /	Summer solstice - 15 Du'uzu	Winter solstice - 15 Tebetu	Shadow Length (cubits)	
15 Tešritu (Equinoxes)				
2 B 15	2 B	3 B	1	
1 B 7;30	1 B	1 B 15	2	
0 B 25	0 B 20	1 B	3	
	0 B 15	0 B 22;30	4	
	0 B 12	0 B 18	5	
	0 B 10	0 B 15	6	
			7	
	0 B 7;30	0 B 11;15	8	
	0 B 6;40	0 B 10	9	
	0 B 6	0 B 9	10	^^^
	Actually winter solstice values	Actually summer solstice values		Sunrise

Table 9: Shadows

It is not stated exactly how large the object is which is having its shadow measured – rather it should be assumed that the shadow lengths in cubits are simply relative.
The closer the sun is to the horizon, the shorter shadows are – more of the ground is obscured behind the object. They are at their shortest when the sun is directly overhead, so at noon. The very first problem can thus be seen on the list with regards to the winter solstice – 3 *bēru* implies 6 hours after sunrise.
In the regularly used system, since the winter solstice day:night ratio is 1:2 according to Babylonian tablets, it means that the day is only 8 hours long. Noon, should occur midway, after 4 hours of daylight, thus 2 *bēru*, and the shadow length afterwards will increase again. This is not the case in the list, however – the shadow length continues to decrease up to the 3 *bēru* mark.

Of course, the nature of the data in this list points to a very different assumption – that the scribe used, as his ratio for day to night on the solstices the value of 3:2 rather than 2:1, the value Neugebauer (1947: 38) tried to prove the use of in terms of astrolabe water clock measurements. This is in fact very close to the correct ratio for a location with Babylon's latitude, and this text is the earliest available example of this ratio being used.

Even if one does assume the more appropriate ratio of 2:3 for the winter solstice values, the day is 9.6 hours long, and noon should occur after 4.8 hours. The columns for summer and winter solstice have, in fact, been swapped around (Hunger & Pingree 1999: 80).

Upon closer examination, length of the shadow multiplied by the time in bēru gives the exact same value for a specific date. The implication of this fact is quite important – the data in this text was not all observed and measured – it was calculated. The values are too perfect. It is also highly unlikely that a person going through the trouble of painstakingly recording such values would get their own dates mixed up. This "perfection" of the data is highly in contrast to the approximations of the first few sections of Tablet I – as Hunger & Pingree (1999: 80) point out, when calculated values would equal amounts of NINDA not writable in the base 60 system, they are left out rather than rounded off. It is for this reason that the equinoxes stop at shadow lengths of 3 cubits – 4 cubits would occur at 13;22 and a half (with no value smaller than NINDA a half was impossible to write), and also why there are no entries for shadows 7 cubits long.

As an astronomical text, section XV is sparse on information. It is simply made known that shadows decrease in size throughout the day, and have different relative sizes throughout the year (or, inversely, that they have equal lengths at different times of the day). While this is tied to an important astronomical phenomenon, the movement of the Sun, it seems a trivial addition. As a scientific text, however, it is remarkable. The 3:2 shadow ratio implies that the author of this text was aware that the day:night ratios for solstices were not 2:1 as previously believed – 3:2 also happens to be basically correct for Babylon. Also, the extremely precise nature of the data implies not only a scientific mind-frame, but that of a perfectionist. Considering that many of the values were likely calculated, rather than observed, simply adds to this view of precision – it indicates a dedicated drive to find out what is real.

5.2.8 SECTION XVI – NIGHT, MOONRISE AND MOONSET

The final section of astronomical data in MUL.APIN, tablet II, begins on the 43rd line of the second column. Information is presented in couplets of lines:

ii.43. On the 1st of Nisannu a night-time watch is 3 minas 10 shekels; 12 UŠ 40 NINDA setting of the moon
ii.44. On the 15th of Nisannu a night-time watch is 3 minas, 12 UŠ rising of the moon

Each couplet follows this basic format, listing the length of the night on the 1st and 15th of each month, and describing period of time it takes for the moon to set after dark on the 1st (it should be new moon) or rise after nightfall on the 15th (when it should be full moon).

Date		Length of the Night (minas;shekels)	Sunset to Moonset (UŠ;NINDA)	Sunset to Moonrise (UŠ;NINDA)
1	Nisannu	3;10	12;40	
15	Nisannu	3		12
1	Ajjaru	2;50	11;20	
15	Ajjaru	2;40		10;40
1	Simanu	2;30	10	
15	Simanu	2;20		9;20
1	Du'uzu	2;10	8;40	
15	Du'uzu	2		8
1	Abu	2;10	8;40	
15	Abu	2;20		9;20
1	Ululu	2;30	10	
15	Ululu	2;40		10;40
1	Tešritu	2;50	11;20	
15	Tešritu	3		12
1	Ahrasamnu	3;10	12;40	
15	Ahrasamnu	3;20		13;20
1	Kislimu	3;30	14	
15	Kislimu	3;40		14;40
1	Tebetu	3;50	15;20	
15	Tebetu	4		16
1	Šabatu	3;50	15;20	
15	Šabatu	3;40		14;40

1 Addaru	3;30	14	
15 Addaru	3;20		13;20

Table 10: Sunset to Moonset / Moonrise

As far as lengths of the night go, this section returns to the original ratio of 2:1 for day:night and vice-versa on the solstices. Not only that, it makes it clear that the increase and decrease of minas / shekels of water in the water clocks were supposed to empty at a constant rate. This list is really an extrapolation of already known data, but instead of listing only the weights of water for the watches on the colures, it lists them for every 15 days – the rate it took for 10 shekels of water to empty out.

The new information, as such, is the information presented on the times it takes for the moon to rise or set respectively after nightfall. It indicates that the Babylonians were aware of the relation between the periods of the Sun and Moon – the longest difference in time between sunset and moonset occurs on the longest night of the year, the shortest difference on the shortest night of the year. Not only that, but the differences in the times between moonrises and moonsets followed on one another, and were extremely linear – the rate of change was constant.

Despite how simple the list appears, it is possible that the values listed were calculated rather than observed – once a few constants have been calculated for this list, the rest are very easy to simply fill in. If that was the case, it may also be possible that the rates of changes for the watches of the night may have been assumed, which would make this text less disruptive to Neugebauer’s (1947: 38) theory of water clocks.

In terms of scientific approaches, then, the list might be seen as a rushed text originating from short-cut methodology, something which an individual wishing to state the absolute truth would avoid. If this was not the case, and the text was created from observational data, then it is an exercise in systematic categorization like many others. It should be notes that the text itself does not serve much more practical purpose than any text simply listing the colures – it exists simply because someone thought the world would be a better place if everyone knew the periods between sunset and moonrises or moonsets.

5.2.9 SECTION X – OFFERINGS AND HORSES

Though section XVI is the final astronomical source in MUL.APIN, there are still two sections of the tablet II which have not been covered. The compilers of MUL.APIN thought it necessary to include them in this compendium of astronomical knowledge, however, so they shall be investigated in brief. The first appears on lines 25 to 45 of the first column. An example of the information presented is given:

i.25 On the 10th of Ululu the star of Eridu becomes visible, on the 15th ŠU.PA;
i.26. on the day their stars become visible you observe their risings, their glow and
i.27. their (untranslated), and the wind that blows; you guard the horses
i.28. so that they do not drink water from the river.
i.29. When their stars have been made visible,
i.30. you present offerings to them; horses
i.31. will touch bitumen and drink water from the river.

The rest of the section contains almost identical information, simply changing the respective dates and constellations. This is clearly not, by modern definitions, an astronomical text. It requires the observation of astronomical bodies, but has nothing to do with the pursuit of recording of knowledge. It is, quite clearly, a text serving a religious function. From the text, it is clear that the heliacal risings of the stars were somehow special. When the star becomes visible, it is necessary to present offerings to it, or at least to the god it represents. Though the text commands to watch for other signs (such as the glow of the stars), it does not explain exactly what to look for with respect to these signs, or how the consequent actions should change. For some inexplicable reason, ŠU.PA, Eridu and the five planets all seem to have influence over horses, or at least over horses' appetite for bitumen. Whether this was an aspect of all stars, or at least the stars in terms of gods, is unclear.

In terms of hoping that the Babylonians were approaching astronomy from purely more from the scientific angle, the inclusion of this text into the great astronomical compendium of its day is a heavy blow. Clearly, the stars were not just vaguely associated with the gods, but were so deeply steeped in the religious consciousness that they were even made offerings to. The effect of not making these offerings – a negative impact on horses – is completely illogical and unscientific. One can only hope that the compiler of MUL.APIN inserted this text simply because it was based on astronomical observations (heliacal risings), and not because it was deemed an important element of the corpus.

5.2.10 SECTION XVII – OMENS

The second of the two non-astronomical sources in MUL.APIN also happens to be the very last portion of the compilation, spanning from the 16th line of the third column to 12th line of the fourth, including an 8 line gap.

It starts with the line:
iii.16. If the light of the stars is red, the irrigated land will prosper.

This is, most certainly, an omen - it follows the general pattern of protasis-apodosis, an if-then statement. All of the omens listed in this final section of MUL.APIN are, as can be expected, related to astronomical phenomenon, though wind needs to be included in the definition. As with other omen texts, the signs seem to have little logical links to the effects.

In connection with section X, two linked omens should be mentioned:
iii.23. If the UR.RI.RI star approaches the Chariot, horses will die.
iii.24. If the UR.RI.RI star approaches the Furrow, the same.

Horses, without doubt valuable assets to society, are the only animals to be mentioned several times within MUL.APIN’s religious and astrological sources. MUL.APIN’s other omens, for the most part, also focus on the effect of the stars on the greater society - mostly the king and the land.

iii.33. If Jupiter is bright: rain and flood.
iii.41. If the Sun sets in a nīdu-cloud, the king will die.

All forms of astronomical body, it appears, are listed harbinger for Earthly events within MUL.APIN, be they stars or planets, the Sun or the Moon. Not all the entries within section XVII are true omens, however; one in particular is more similar to the commands of section X, but is in this case compliance is optional:

iii.35. On the day the Lisi-star becomes visible, a man should wake up at night all that is around his house
iii.36. people, cattle, sheep and donkeys,
iii.37. and he must not sleep; he should pray to the Lisi-god, then he and all that is around his house will experience success.

For the most part, the omens listed in this section have physically possible protasis, but there are a few exceptions:

iii.48. If a star passes from the West to the East, for 3 years the land will experience evil.

This event is ominous, of course, because it goes against the norm, but it is not only unlikely; it is impossible. How it was determined what the effect would be if this were to occur is difficult to fathom.

Unlike many other omen texts, MUL.APIN does not offer a counter-condition to its omens. It lists the effects, such as the death of the king, but does not describe any form of ritual to prevent this from happening.

In all, the astronomical bodies of section XVII are listed as harbingers mainly of weather conditions (like irregular flooding patterns), deaths (and diseases); wars (and revolutions) and every so often, prosperity.

6. RELATED TEXT AO 6478

While later Babylonian texts of mathematical astronomy (such as the Ephemerides) are not of application for the current investigation, there are a few texts of later origin that do deserve mention due to the similarity (and progression) of the content. One such text is known from two tablets, K.9794 (from Assyria) and AO 6478 (late Uruk) (Horowitz 1998: 182). Of these, however, only AO 6478 is viable for use, as K.9794 is a fragment of only 19 lines. The astronomical data is introduced in the second line, and is translated:

“The distance between *ziqpu* stars that stand in the Path of Enlil in the middle of the sky opposite the one who observes the sky, and the rising and setting of the stars that he sees in their midst at night” (Horowitz 1998: 183).

Immediately a connection can be drawn to tablet I, section VI of MUL.APIN – this source also deals with *ziqpu* stars. However, unlike the lists of MUL.APIN, AO 6478 does not list easily observable data such as concurrently rising constellations, rather, it lists the measurable distance between the various *ziqpu* stars. Where this list is particularly unique is that it introduces two completely new terms:

UŠ ina qaqqari (UŠ / degrees on Earth – possibly should read “sky”)
Bēru ina šamê (bēru / leagues in heaven)

For each period between stars, measurements are given in *minas* of water, *UŠ ina qaqqari* and *Bēru ina šamê.*

The following table has been derived from a similar table of data presented in (Horowitz 1998: 84).

From Star	To Star	minas	UŠ ina qaqqari	Bēru ina šamê
ŠUDUN	ŠUDUN ANŠE EGIR	1;30	9	16200
ŠUDUN ANŠE EGIR	GAM	2;00	12	21600
GAM	šá-maš-a	2;30	15	27000
šá-maš-a	šá-taš-ka-a	0;50	5	9000
šá-taš-ka-a	DELE	1;40	10	18000
DELE	GAŠAN-TN	1;40	10	18000
GAŠAN-TN	UD.KA.DUH.A	3;20	20	36000
UD.KA.DUH.A	ni-bi-i šá GABA-šú	1;40	10	18000
ni-bi-i šá GABA-šú	kin-i	3;20	20	36000
kin-i	a-si-di	3;20	20	36000
a-si-di	lu-lim	1;40	10	18000

lu-lim	um-mu-lu-ti	2;30	15	27000
um-mu-lu-ti	ni-bi-i šá ŠU.GI	2;30	15	27000
ni-bi-i šá ŠU.GI	na-sa-ra-pi	1;40	10	18000
na-sa-ra-pi	GÀM	2;30	15	27000
GÀM	KIŠIB GÀM	1;40	10	18000
KIŠIB GÀM	MAŠ.TAB.BA	5;00	30	54000
MAŠ.TAB.BA	5 UŠ…bi-rit MAŠ.TAB.BA	0;50	5	9000
5 UŠ…bi-rit MAŠ.TAB.BA	AL.LUL	3;20	20	36000
AL.LUL	MUL.MEŠ šá SAG.DU MUL UR.GU.LA	3;20	20	36000
MUL.MEŠ šá SAG.DU MUL UR.GU.LA	MUL 4 šá GABA-šú	1;40	10	18000
MUL 4 šá GABA-šú	MUL 2 šá GIŠ.KUN-šú	3;20	20	36000
MUL 2 šá GIŠ.KUN-šú	DELE šá KUV-šú	1;40	10	18000
DELE šá KUV-šú	A.EDIN	1;40	10	18000
A.EDIN	ŠUDUN ANŠE	4;20	25	45000
ŠUDUN ANŠE	ŠUDUN	1;20	8	14400
Total		60;40	364	655200

Table 11: Stellar distances

The values for the difference in minas of water is quite straight forward, they indicate the amount of time between one constellation and another are overhead, but it should be noted the water clock outflow rate is not identical to those used to measure entire watches. Here, one mina of water empties in about 24 minutes (rather than 240 minutes). The units of most interest, however, are the degrees, or UŠ. The modern definition of a degree is derived from UŠ, and as previously mentioned, stars come out one UŠ / degree (4 minutes) earlier each night. When adding the totals for *UŠ ina qaqqari*, unlike regular UŠ, the total is equal to 364, not 360. 360, after all, is an ideal rounded value used simply for its ease of application in the base-60 (hexagesimal) system. By implication, since one rotation of the sky is made up of 364 UŠ, the length of duration for a day is now off. However, the value for one year, when considering that stars rise one UŠ earlier each day, is now much closer to the real value – 364 days is a much closer approximation to a year’s length than 360. The value for the variant *UŠ ina qaqqari* was perhaps thus slightly different from the regular UŠ, but it is difficult to determine.

What is of even more interest, however, is the value for *Bēru ina šamê*. Generally, 30 UŠ = 1 *bēru*. However, for AO 6478, 1 UŠ is equal to 1800 *bēru*. As such, there is only one possibility: the *bēru* here indicate actual distances (Horowitz 1998: 185).

When *bēru* is used to indicate distance, instead of 2 hours of arc, it measures 2 hours of walking distance. This was explained in Section 3.3: Etana and the Eagle, and per se, one *bēru* is approximately equal to one league (which Horowitz here in fact uses), or 5 kilometres. The proposed distances between different constellations, therefore, is quite vast (though, in truth, nowhere nearly vast enough).

In view of scientific approaches, the Babylonian mindset has clearly evolved somewhat. Not only is a water clock used which will give more accurate measurements for smaller amounts of time, but the introduction of the new variation of UŠ is clearly an attempt to fix the flawed Babylonian year. In view of the inclusion of linear distance into space, an opinion on the scientific approach has to remain neutral. Whether these values were somehow calculated or were arbitrarily decided upon is unknown.

Amazingly for a scientific, astronomical text, the most important consequences are, in fact, cosmological. The reason for this is as follows.

Since the ratio of distance:degrees remains constant, the Path of Enlil along which the *ziqpu* stars travel has to be a perfect circle. Whether the Babylonians were aware of this fact is uncertain, but relatively likely. By adding all the differences in *Bēru ina šamê* together, by arriving back at the start, one has in fact travelled the entire circumference of the Path of Enlil.

Modern mathematics states that the circumference of a circle is equal to the radius multiplied by 2 π. The Babylonians did not know this ratio, but they nevertheless did have a formula of their own for its calculation, the radius multiplied by 6 (which is close enough, 2 π equals roughly 6.28). This means, since the circumference is known, the radius of the circle can be calculated;

radius = 655 200 divided by 6
= 109 200 *bēru*.

The radius of the circle has an important implication: it is the distance of the observer to the distance of the *ziqpu* star itself. As such, the distance from the Earth's surface to the Lower Heavens of the stars was 109 200 *bēru*, or 546 000 kilometres. This is, quite frankly, a huge jump from the 3 *bēru* the eagle flew to the even higher Heaven of Anu in the Etana Epic mentioned in Section 3.3: Etana and the Eagle.

7. THE SCRIBES OF ENUMA ANU ENLIL

In order to determine whether the scribes of the older Babylonian astronomical corpus possessed, or at least were starting to show signs of, a scientific frame of mind, it is the evidence itself which has been of most influence: in other words, the appearances of hints towards this state of mind within the texts themselves. However, just like these views were likely altered by the scribes' cosmological beliefs with regards to the stars themselves, the chances are also good that they could have been influenced by other factors within the lives of the scribes. Before it can be determined exactly to what degree the scribes were adopting scientific frames of thought, it is perhaps prudent to briefly discuss exactly who and what these scribes were, in case these deductions nullify the conclusions already drawn.

Firstly, scribes held an extremely formal position. The term did not indicate a person simply capable of reading and writing at the same status as the rest of the general citizenry - all scribes were employed by the king; they formed part of the social elite and were mostly the sons (though women are attested for) of men of prominence (Pearce 1995: 2265). During the times of the composition of the earlier Babylonian astronomical corpus, scribal activity was conducted, for the most part, in the palace itself (Pearce 1995: 2273). In order to be a scribe, or *tupšarru,* it meant that one would have to have knowledge of the greater body of texts of the scribal repertoire, known as the *tupšarrūtu* (Rochberg-Halton 2004: 210), and forced scribes specialising in certain fields to have knowledge of certain core texts. Of the texts discussed, *Enuma Anu Enlil* was one such "text book," and it is possible that MUL.APIN may have been another.

For the most part, scribes tended to form a separate level of society that was, for the most part, quite exclusive (Rochberg-Halton 2004:213). This stretched as far as the texts themselves – many were meant to only be read by other scribes. One such text, to name an example investigated, is KAR 307. It states in its opening line that the tablet is the "secret of the Great Gods," and further "let the knowing reveal it only to the knowing, do not let the unknowing view it, it is a taboo of the Great Gods" (Horowitz 1998: 5). Similar lines can be found amongst many other texts, particularly those dealing with topics live divination, magic, medicine or, more importantly, astronomy (Rochberg-Halton 1995: 217). The implication of this is that the astronomical knowledge presented in the previous texts was likely known only by the scribal class of society, and as such, astronomy was by no means a facet of the lives of the common populace.

Many scribes held very important positions in society, the highest being the advisor to the king (Rochberg-Halton 1995: 223). Such advisors, it is recorded, were expected to be able to advise the king in matters of rituals, divination and astronomical works (Nemet-Nejat 2002: 203). As such, considering that scribal knowledge was kept within one's own field of the "knowing," astronomy and astrology fell under the field of study of the same school of scribes (Nemet-Nejat 2002: 203). As suspected from the intermingled nature of astrological and astronomical data within the majority of texts, they were considered aspects of the same thing (Rochberg-Halton 195: 223). The names given to the scribes of this particular school were *tupšar Enūma Anu Enlil*, the Scribes of Enūma Anu Enlil (In CAD [T] (19:151) - *tupšar Enūma Anu Enlil*, the term is described as "astronomer")

The name of this body of scribes obviously implies that their primary function was to have knowledge of omens. Astronomy, as such, is not as important to Babylonian society as astrology. To clear any doubts, in the colophons of the purely astronomical texts of the later period, the scribes often refer to themselves and their position as a *tupšar Enūma Anu Enlil.* The term remains associated with the astrologer/astronomer scribes right up until the very last known texts of Babylonian astronomy.

The scribes who wrote the texts under investigation thus had a wide field of knowledge. Firstly, they were expected to know the details of the heavens; the periods and movements of the astronomical bodies. They were expected to know how to interpret what could be seen in the heavens in terms of what the supposed implications of such signs could be. Lastly, they were expected to know what to do to counter each specific sign if it has bad connotations. A good example of this was to install a substitute king on the throne if a sign was received that the king was going to die (Rochberg-Halton 1995: 78). This substitute king (usually a criminal) would then be executed after a while in order to ensure the prophecy came true and the real king would be safe. Amazingly, if the real king died before the execution/sacrifice, the substitute (criminal or no) would remain king.

As a class in its entirety, the scribes of the astronomical texts cannot be declared scientists in the modern sense of the word. Their principal functions revolved more around divination, and their astronomical knowledge was used simply to supplement it. However, none of this information argues against the idea that individual scribes did not possess scientific frames of mind, nor does it imply that the approach to the information could not gradually become more scientific. While the corpus itself was by no means scientific, it did not specifically impede the awakening of scientific thought processes. As such, the conclusions drawn from the texts themselves remain in place.

8. CONCLUSION

Science, as has been defined (Section 1), is the study of the structure and behaviour of the world. It is the study, as such, of the nature of everything that can be observed. By implication, it is the study aiming to learn how physical reality works. To have a scientific frame of mind, therefore, implies a desire to know the structure and behaviour of the world and want to know how everything works

The preceding investigation has been an attempt to identify this scientific frame of mind amongst the early Babylonians, by focusing on their views of the stars before the date of 700 BCE through the texts originating from this period dealing with the subject in question.

The people of whom the mind-frames were investigated were naturally the scribes of the texts themselves. Later investigation of the nature of their occupation in fact made it clear that in terms of views on the stars, the scribes were in fact the only choice, for access to texts dealing with this aspect of physical reality was mostly restricted to members of their profession (Section 8).

The requirements of their profession meant that they were often involved in actions which were not only unscientific but in fact went against the principles of science, drawing conclusions about reality (in this case the future, through divination) without having been able to study and observe it. As such, classifying them as true scientists is impossible. This does not, however, mean that individuals were disqualified from possessing scientific frames of mind.

Since conceptions of reality are often influenced by local ideology (be it forced or simply through constant or early exposure), the popular and official traditions which the individual would have been exposed to before his entry into the scribal school have been included in the investigated (Section 3). These would form the basis of what the scribe believed the nature of the subject into which he would be delving was; in this case, what the stars were believed to be. The view of the stars presented by such texts as *Enuma Elish* (Section 3.1.1) and the tradition of the Three Heavens (Section 3.2) indicate a generally accepted cosmology in which the assignment of aspects of the nature of the stars – their origin (Section 3.1.1 and Section 3.1.2), position in the sky (Section 3.2) and height above the world (Section 3.3) – appear to be completely arbitrary. Only in the case of the sky, its colour being similar to a blue stone (and thereby the association of the sky with the stone – Section 3.2), can the reasoning behind one of these aspects of belief be seen. Association, however, is far from evidence. As such, the general Babylonian populace was exposed to a system of understanding the universe where study and the acquisition of evidence was not the norm. The construction of scientific mind-frames would thus not be a factor of society, and any inclinations towards them would rely solely on the inherent nature of the individual.

For this purpose, the investigation of whether individuals possessed scientific frames of mind has centred upon the texts they wrote, of which the following can be said:

Scientific mind-frames desire to know how the world around them works. By implication, if aspects of the functioning of the world are identified, it means that an individual with a general interest in the phenomena set out to figure out how it works. Remarkable discoveries listed in the texts of the Astrolabes (Section 4.2), *Enuma Anu Enlil* (Section 4.1) and MUL.APIN (Section 5) include that fixed stars travelled along set courses in the sky, and returned to the same position in the sky at a regular interval (one year) (Section 4.2) rising exactly 4 minutes earlier each day (Section 5.2.5); also that planets like Venus had similar periods (Section 4.1), and that the time ratio of the longest to the shortest day every year remained the same (even if they got that ratio wrong), and that the Sun shifted its position in its orbit at a constant, progressive rate (Section 4.2). Such discoveries would usually provide enough of an argument to end an investigation of such a matter, but unfortunately, the existence of astrology, which did not tie itself to specific stellar phenomena but to the movement of stars in general, meant that many of these discoveries may have been made not due to the aforementioned curiosity of how the world works, but rather for the explicit purpose of determining what observations would influence the future in what ways (determining omens, as in Section 5.2.10).

Since scientific minds wish to know exactly how the world works, they tend to categorize similar subjects of observation into groups in order to better understand their relations to one another. In terms of the stars, this was done on many levels, the most basic being that constellations were catalogued into three different paths in the sky determined by their positions (Section 4.2). In order to better understand these relations, most observations were entered into systems or catalogues, such as in the astrolabes (Section 4.2) or the MUL.APIN lists (Section 5), including data related to such aspects of the stellar observations as which stars rose when others set (Section 5.1.4), which stars would pass directly overhead at dawn (Section 5.1.6), and which stars were touched by the Moon in its travels throughout the sky (Section 5.1.7), to name but a few. Unfortunately, while the scientific mind is the type to categorize and list purely out of interest, astrologers would still do the same in order to determine which phenomena had what possible result – just because the lists of data in MUL.APIN do not contain apodoses, does not necessarily mean that they were not created for divinatory purposes.

Generally, a person with a more scientifically-inclined mindset will crave greater accuracy to better fulfil his understanding of the nature of the world. In this regard, the texts of MUL.APIN unfortunately still disappoint – many of the values are approximations (Section 5.1.2), mostly with respect to dates, and as such what is presented is far from reality. The section on the compass (Section 5.2.5) provides information which is simply wrong, so there is little chance of a thorough, inquisitive mind behind this source.

Some other texts, on the other hand, are extremely accurate (or at least precise), such as the Shadow Clock (Section 5.2.7). The Shadow Clock by itself presents quite a few indications of scientific methodology at work. While the data is accurate, the nature of the data (the length of shadows at specific times of day) means that it is ironically also almost completely useless with regards to any possible practical application, even with respect to divination. While it could be applied to determining of dates by calculation of the day:night ratio for the day in question, much simpler methods to determine the same thing existed; and as such the existence shadow clock may owe its existence solely due to the desire of a single scribe to interlink the various aspects of physical reality. As such, it implies an origin in individual interest, a strong indicator of a scientific mind-frame.

This is further evidenced by that fact that the longest:shortest day ratio changes to a more correct value than the ones used in many of the other MUL.APIN sources, since the scientific mind is never content to accept a system unconditionally; if any aspect is seen not to fit in the system as originally assumed, the system will be re-evaluated and data possibly dropped from the system. In the same manner, redundant *ziqpu* stars are removed from their list in Section 5.1.6.

The opposite is also true – the scientific mind will embrace new data or even adopt completely different systems in order to acquire more knowledge. AO 6478 (Section 6) is one such text in which an entirely new system (and using revised equipment) is used. Scientific minds crave progress. By the implications drawn from this text, a completely new value for an old cosmological idea (the height of heaven) is even given.

Sadly, just as the texts show examples of progress, some also show signs of stagnation. Social implications (such as being branded a heretic) aside, the inclusion of Jupiter into the Path of Enlil rather than Anu, just to conform to the original system mentioned in the *Enuma Elish*, is completely contrary to scientific values and beliefs, almost as bad as intentional falsification of data as shown in Section 5.16.

Finally, the scientific mind will strive to gain as complete a picture as possible from that which it observes. In terms of the astrolabes (Section 4.2), which have practical applications as a form of calendar, single heliacally rising stars could have been presented each month and the text would still serve the same purpose. However, stars are included for each of the three different paths in the sky, and a water clock table is included as yet another alternative.

With respect to whether or not the Babylonians possessed a scientific frame of mind with reference to the early observations of the heavenly bodies, it can therefore be deduced that one portion of the civilization, the scribes, did in fact shows signs of a scientific frame of mind, yet it varied from one scribe to another and was not by any means the most commonly attested.

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