

Treatise on the Biblical Calendar, first edition (abbreviated TBC1)
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[1] Preface

This is the first edition of this general treatise on the biblical calendar. It does not presuppose that the reader is already familiar with various aspects of the biblical calendar. It begins with the most basic matters and gradually fills in the details in an orderly fashion, never requiring the reader to know something that will be explained later. The main companion to this is a literal Bible translation and a concordance with Strong's numbers.

It is anticipated that eventually other related topics will be added in subsequent editions. In recent months I have been gathering my varied notes into this unified whole for the occasion of the unusual event toward the end of March 20, 2007, namely, the expected appearance of the new crescent over Israel, and subsequently, several hours later, the astronomer's calculated moment of the vernal equinox. The immediate purpose of this treatise is to cover sufficient details of the biblical calendar, so that this unusual event may be judged by the reader according to the evidence presented. The evidence presented will show that March 21 is both the new moon day and the day of the vernal equinox, so that March 21 is the first day of the first month.

For those readers who already have significant knowledge of the biblical calendar and desire a summary of how the conclusion is attained, I will now refer to the chapter numbers. Chapters [10] through [14] are important for some conclusions that have a bearing on the whole matter. Here the key is the lack of mathematical astronomy by ancient Israel. Chapters [21], [25], and [27] through [30] relates to the observational process and the communication process that pertains to the day of the new moon and its practical dissemination in ancient Israel. Next see chapters [35] and [36] for the biblical understanding of the vernal equinox. Chapters [38] and appendix A go together, and these are very critical in the whole effort to understand the relationship between the day of the vernal equinox and the first day of the first month in the Babylonian calendar. Chapter [41] is very important to see the corroboration of chapter [38] from a first century witness. Finally, chapter [42] ties together all the parts and gives separate evidence independent of the detailed computer calculations in the appendix. People who distrust computers should easily see the simple logic here. If the very knowledgeable reader desires to see the final summary in a nutshell, just go to chapter [42] and also to appendix A.

I grew up in New York City and was the son of Jewish parents, who sent me to a Hebrew school after public school hours for six years. The highlight of this training was learning elementary biblical Hebrew. In adulthood I earned an M.S. degree in Mathematics from the University of Arizona. My profession is software engineering. This background served me well in later biblical, astronomical, and calendaric studies.

The order of presenting the subject is critical to aide in logical reasoning and especially to avoid circular reasoning. I avoid writing anything that uses a result that is claimed to be proved later, because that approach can lead to circular reasoning. An appendix that is focused on a single self-contained technical topic may be read at the time it is first mentioned in the body of the text, and is therefore not considered to violate the concept of proceeding in a logical order without resorting to conclusions based upon what is written later.

The meanings of certain Hebrew words in the Bible are especially significant for an understanding of the biblical calendar. Archaeological discoveries concerning ancient Semitic languages were achieved in the 19th and 20th centuries, which are important toward recovering the meanings of certain Hebrew words. One chapter is devoted to this in order to explain the reason for the importance of ancient Semitic languages.

Acknowledgements

This study began in the summer of 1967 while examining some volumes of *Scripta Mathematica*, a journal of Yeshiva University. This journal of mathematics had some articles as well as reviews of books concerning the mathematics and the history of the Jewish calendar. I was amazed that such material would appear in a serious mathematics journal. My interest and curiosity in the subject was kindled at that moment, and I gradually acquired a growing collection of books and articles on the biblical calendar and the Jewish calendar. This igniting moment happened at the library at the University of Arizona in Tucson while I was pursuing graduate work in mathematics. At that moment I never expected that this study would eventually consume thousands of hours of my time and naturally branch out into long-term studies into Josephus, Philo, the history of astronomy and ancient calendars, the Dead Sea Scrolls, the agriculture and climate of Israel, Rabbinical writings, etc. Major research libraries made this possible, and

thus a significant acknowledgement must go to the multitudes of libraries that I visited, often until closing time. On several occasions I visited the library at Hebrew Union College in Cincinnati and later utilized their photocopy services for out-of-town requests. Institutions of higher learning in greater Dallas and Fort Worth, Texas, in Louisville, Kentucky, and in greater Los Angeles were indispensable over the years. I also made several visits to the libraries at the University of Texas at Austin and the University of Chicago.

During the years 1980 through 1982 my friend Rob Anderson caught the biblical calendar interest as well, and he volunteered to write a computer program that ran on a Hewlett-Packard HP-3000 minicomputer that would approximate the visibility of the new crescent based upon Karl Schoch's curve. The software that he wrote was based upon the bibliographic reference Van Flandern and Pulkkinen. His many and varied computer studies were a significant help to understand how the astronomical circumstances for the calendar changed for the first month and the seventh month, the minimum and maximum time from the astronomical new moon to the sighting of the new crescent, the time from sunset to moonset on days that the new crescent would be seen, the date that the biblical festivals would fall based upon a calendar of simulated visibility, the relationship between the time of the new crescent and the full moon, etc. He and I discussed many aspects of the calendar in those years, and also the astronomy of the moon. Rob also made some visits to various libraries for specialized related subjects. In September 1982, using some of the tabulated results of the studies that Rob Anderson produced with his creative software, the book titled *The Calendar God Gave to Moses* became a reality. Although I wrote nearly all the words and determined the arrangement of the chapters, all of the statistical data concerning the calendar came from Rob Anderson's efforts; thus its authorship was listed as "Herb Solinsky and Rob Anderson". The present treatise will occasionally make reference to Rob Anderson, and though his work stopped in 1982, that effort still lives on for acknowledgement in this treatise. Initially 400 copies were dispersed, but over the years several times that number were sent out. Jack Hines from Colorado Springs, Colorado and John Trescott from Anadarko, Oklahoma also sent out significant numbers of that 84-page book from 1982 over the years. Rob Anderson's use of the HP-3000 computer was no longer available, and astronomy software needed to be pursued.

My studies on the calendar never ceased after 1982 with that 84-page book. There was never any reason to change the overall conclusion of that study, but I certainly began to grasp many aspects of this in much greater detail and with better explanations. As the scholarly community began to fill in the gaps in the history of Babylonian and Greek astronomy, I soaked this up and saw how to use some of this material to narrow down the reasonable choices related to the history of ancient Israel and the biblical calendar. The present study represents a major leap forward into some areas that I could not foresee in 1982. While this first edition does not include extensive study into the meaning of “abib” and the agriculture of barley in Israel, I have already written extensively on this in a separate monograph during 2001-2004, and the next edition of this treatise will include a rearrangement of that material along with some newer related material on the wave sheaf offering. I anticipate that this treatise will grow to at least three times the size of the 1982 study, and its contents will include so much that is new, that it should have a new title. This is not merely a revision of the 1982 study, but a leap forward, addressing certain areas whose surface was only scratched at that time.

In early 1995 I began to explore astronomy software for use with the personal computer. I want to thank John Mosley, the Program Supervisor at Griffith Observatory in Los Angeles. He was very kind and patient with me as he answered my questions over several telephone calls about various astronomy software packages. He had tested and reviewed many software packages for *Sky and Telescope* magazine. He advised me that LoadStar Professional was the most accurate software available for the moon with an IBM PC compatible computer, including ease of use. It does use the JPL (Jet Propulsion Laboratory) results for accuracy in the distant past. This is DOS based rather than Windows based, and it has never been upgraded, so that its graphics is primitive compared to what is currently available. Nevertheless, its accuracy still serves my needs very adequately.

On May 4, 1995 I was very thankful that I was able to spend 30 minutes over the phone speaking with Professor Bradley E. Schaefer, who, in my opinion is the most knowledgeable person alive on technical matters relating to the visibility of the new crescent. I learned much from that phone call, and some of his publications that were helpful are listed in the bibliography. He was the first one to alert me about the need to consider humidity as a significant factor for the ability to see the new crescent.

In mid-September 1982 I had a desire to speak with Professor Otto Neugebauer about the history of the Jewish calendar from before the destruction of the Temple in 70. I telephoned the History of Mathematics department at Brown University, and he himself answered the phone!!! My desire was satisfied and I thankfully acknowledge his assistance and willingness to speak with me.

In the summer of 1992 I noticed that there was an agricultural experimental station that was labeled as an extension of Texas A & M University, located in Plano, Texas. After contacting this facility by telephone, I was transferred to Professor David Marshall, who is a grain geneticist, specializing in wheat and barley. He invited me to visit him at his office, and I happily accepted for the purpose of learning more about barley, including how and when it ripens. I was mentally sky high as he loaned me a tall pile of his personal books about barley and grains. He told me that I should look into the genetics of barley because different varieties ripen at different times. I followed his advice, and later that year I spent nearly three days at the library of Texas A & M University in College Station. I am grateful to David Marshall.

In November 1997 I received a telephone call from Jack Hines explaining the need to make computer projections of the biblical festivals through the year 2010. At his suggestion he and I agreed to independently use different software to apply Karl Schoch's curve and then compare dates and reconcile differences in order to reach agreement. We did this, but in the process of reconciling differences and discussing the options in the software that he was using, I learned more about the meanings of certain astronomical coordinate systems. I thank Jack Hines for his useful suggestions, his participation, and his encouragement.

Useful discussions transpired with Wayne Atchison, Phil Frankford, Steve Rathkopf, and Jim Sorenson.

[2] Goals of this Study and the applied Philosophy to attain these Goals

There are two broad and primary goals of this study. The first is to discover the nature of the calendar that was used by ancient Israel, i.e., the biblical calendar. The second is to expound a procedure that may be applied in today's society by which this calendar (*or one especially "close" to it*) may be used.

The modern calculated Jewish calendar will be abbreviated MCJC. If one considers it worthwhile to replace the MCJC with another calendar, that would only make sense if the proposed replacement was based upon the same principles as the calendar used by ancient Israel, i.e., the biblical calendar. The second requirement for replacing the MCJC is to expound a procedure that may be applied in today's society by which this calendar may be used.

It is important to have a clear stated philosophy of the guiding principles that are to be used to develop a procedure to apply the calendar that was used by ancient Israel. The philosophy used in this study is now presented in the order of the priority of the philosophical principles.

(A) **The Biblical Model.** If the same illustrative astronomical positions and other conditions that occur today were also to have prevailed in ancient times, the decision or conclusion to be determined today should agree as much as possible with the ancient decision in Israel relating to the calendar. The MCJC is weak in this respect, especially because the principles in its calculation do not closely approximate the consistent reality of astronomy. If this biblical model is not given the highest priority in the calendaric procedure, then the procedure will be open to the same criticism as the MCJC and will have no advantage over the MCJC.

(B) **Avoiding Arbitrary Rules.** The proposed procedure should embody a minimum number of subjective rules with an arbitrary decision. The MCJC is weak in this respect because there are many arbitrary rules related to the calculation as well as to the final decision. If this point is violated, then the proposed procedure is justly open to the criticism that it is a relatively fictitious calendar, i.e., it has modern invented rules, and is therefore inherently no better than the MCJC. The criticism of adopting a fictional calendar having subjective and arbitrary rules is a serious one.

(C) **Spiritual Unity.** The proposed procedure should resolve disputes over the date for the festivals in any area of the world, so that if people desire to attend a festival together, then they should arrive at the same date for the holy convocations. This does not require or imply organizational unity of those in attendance; instead, it implies spiritual unity that crosses organizational boundaries. Spiritual unity does not imply doctrinal unity on nearly all subjects, but it does imply a spirit of peace with the ability to

accept people whose viewpoints do not always agree with yours. While it is possible for people to meet together for a festival of tabernacles for which all of their dates only agree upon six of the eight days, that is far from ideal because there is a loss of 25 percent of the feast in full togetherness. Even if some people plan to stay extra days beyond those that they personally consider to be holy convocations, they are likely to avoid certain group activities that conflict with their dates of holy convocation.

There is much in Scripture to support spiritual unity, and at the appropriate place this will be discussed in some detail.

[3] Cognate Words in Ancient Semitic Languages to aide Hebrew

The Bible is the ancient texts of Scripture in its original languages. But unless we can know the ancient meanings of all the words and expressions found in these ancient texts of Scripture, our understanding of the Bible will have limitations. Let us consider how the Hebrew language came to be the language of the Hebrew Scriptures.

About 1900 BCE Abraham left Ur of the Chaldeans to go to the land of Canaan (Gen 11:31; 15:7). This area was about 450 miles northeast of Jerusalem. Gary Rendsburg wrote on page 116 "... Abraham's Ur should be identified with modern Urfa in southern Turkey (near Harran), which not only accords with local Jewish and Muslim tradition, but truly is 'beyond the River,' to use the biblical expression [Josh 24:2]." Maps in most Bibles do not show Ur near Harran where it ought to be. Ur is in a region for which Akkadian was the ancient Semitic language. Abraham, Lot, and their servants with their families brought this primary language of the Middle East with them, but Isaac, Jacob, and his sons' families lived in Canaan where they were a tiny minority in the midst of the Canaanites who did not speak Akkadian. In order to converse with their more numerous neighbors, these descendants of the original group with Abraham had to learn the local language of the Canaanites, and over time it should be expected that their use of Akkadian gradually died out because it was impractical in that environment. Roughly 500 years after Abraham's time, Joshua led the Israelites back into the land of Canaan after their captivity in Egypt. It is not known how much of the language of Canaan they retained during their generations in Egypt, but once they entered the Promised Land, their continuing contact with the native peoples led to further merging of the language of the Israelites with that of the Canaanites. In the review by Galia

Hatav, on page 131 we read, “Saenz-Badillos provides a full survey of the history of the Hebrew language, tracing its origins in the Canaanite period, through a span of 3,000 years, including its modern use in Israel.” Saenz-Badillos wrote, on page 53, “From the moment of its appearance in a documented written form, Hebrew offers, as we saw in the previous chapter, clear evidence that it belongs to the Canaanite group of languages, with certain peculiarities of its own.”

On page 12 of the book by Cyrus Gordon there is a discussion about the ancient city of Ugarit on the eastern coast of the Mediterranean Sea to the north of ancient Israel. This was the capital of the small Ugaritic Kingdom, which flourished from about 1400 to 1200 BCE during the time period of the Judges in Israel. This page states, “Ugarit itself was located near the northwest corner of what we may call Canaan, the land that nurtured a number of linguistically related groups including the Phoenicians and the Hebrews.”

The discovery of the first texts in the Ugaritic language in 1929 is described on page 14 of the book by Mark Smith. On page 15 he mentions that in 1930 a few scholars had assigned certain shaped letters in these texts to equivalent letters in ancient Hebrew. These letter assignments were made based upon the initial assumption that the Ugaritic language was very similar to ancient Hebrew. Once this decipherment was made, the Ugaritic language was easily understood by scholars who knew Hebrew.

While there are some differences in grammar between Ugaritic and ancient Hebrew, these Semitic languages are very closely related. In 1930 a significant library of Ugaritic texts was discovered in the Ugaritic Kingdom. The northern boundary of the ancient Canaanites is unknown, so that leading scholars of Ugaritic studies at the end of the twentieth century are no longer willing to state that the Canaanites spoke the language that is called Ugaritic, but it was surely very close to it, as was biblical Hebrew. On page 1 of the Ugaritic grammar book by Daniel Sivan, he mentions that over 1300 texts have been unearthed from this greater region. He wrote, “At the present time, these clay tablets represent the only substantial second millennium B. C. E. source wholly written in the language of the inhabitants of the greater Syria-Israel region.” On pages 2-3 he wrote that a few scholars hold the view that Ugaritic is a Canaanite dialect, but others maintain that it is an independent language quite distinct from Canaanite. On page 4 Sivan wrote, “Ever since the discovery of the Ugaritic writings many studies have been

written concerning the expressions of style and of form that are common to Ugaritic and Biblical Hebrew literature both in larger literary units and isolated refrains.” Later, on the same page we note, “The profound connection between the two literatures serves to elucidate many difficult passages in the Bible on [the] one hand and points to a common stylistic stock on the other.”

On pages 224-225 of the book by Mark Smith, he wrote, “In retrospect, the Ugaritic texts have fulfilled their promise for biblical studies. No other corpus from Syria to Mesopotamia, no roughly contemporary corpus such as the Mari texts, the El-Amarna letters, or the Emar texts (though these still hold considerable promise!), or even later texts such as the Dead Sea Scrolls, have made the same impact on the understanding of Israel's languages and culture.”

Certain words found in biblical Hebrew have a meaning that is not clearly determined from the biblical contexts. Some of these words have a cognate in the Ugaritic language or in another Semitic language. By a cognate, I mean a word that sounds almost the same in the other language, is spelled almost the same using equivalent letters, is used in similar contexts, and which seems to have a common linguistic ancestry. Additional contexts of the cognate in the other Semitic language often provide clarifications or more precise meanings of some Hebrew words.

In his discussion of Hebrew lexicons, on page 201, Michael O'Conner wrote, “The most important change between them [both the first edition of the Koehler-Baumgartner Hebrew lexicon in 1953 and Zorell's Hebrew lexicon of 1954] and Buhl [his revision of Gesenius' Hebrew lexicon in 1915] was the discovery of Ugaritic [in 1929]: this is well represented in Koehler-Baumgartner 1 and almost not at all in Zorell.” If grammatical care and most especially contextual matching is not followed, then the use of allegedly cognate words to transfer meanings can lead to wild speculations, and some irresponsible scholars have thereby given a foul taste to the use of Ugaritic in biblical studies; see pages 159-166 of the book by Mark Smith who especially points to the abuses of Mitchell Dahood in damaging the reputation of the use of Semitic cognates. Michael O'Conner comments on this negativity as follows on page 203, “It may be that the [irresponsible] excesses of G. R. Driver and Mitchell Dahood are to be blamed for the negative view often taken nowadays of comparative [Semitic] argumentation, but the neglect of such argumentation has had a deleterious

effect.” In other words, abuses of the use of Semitic cognates has led some scholars to want to abandon its use altogether, and this abandonment has been harmful, especially if grammatical care and good contextual matching is achieved.

Another ancient nation on the eastern coast of the Mediterranean Sea and north of Israel is Phoenicia whose language is called Phoenician. As mentioned above in the quotation from the book by Cyrus Gordon, Phoenician was also similar to ancient Hebrew. On pages 58 and 60 of the book by Edward Lipinski, he wrote, “Phoenician is the Canaanite form of speech used in the first millennium B.C. in the coastal cities of Byblos, Sidon, Tyre, in the neighboring towns, and in the various settlements and colonies established in Anatolia, along the Mediterranean shores, and on the Atlantic coast of Spain and of Morocco.”

The language of the Phoenician colonies is called the Punic language, which is also very similar to Hebrew. Later, Aramaic became the language of the Mesopotamian region, but Aramaic was originally an eastern Mesopotamian Semitic language that also has many affinities to Hebrew. Syriac is a later offshoot of Aramaic. The common ancient Semitic languages that are closest to biblical Hebrew in order of closeness are the group of Ugaritic, Phoenician, and Punic, followed by Aramaic, Syriac, and Akkadian. Arabic is another Semitic language that is less close to biblical Hebrew.

The Israelites began their use of Hebrew in the land of Canaan where they derived their language. It was directly north of this area that Ugaritic and Phoenician were spoken. The deities of the Canaanites as mentioned in the Bible, namely Baal and Dagon, are also discussed in Ugaritic along with pagan practices associated with those deities, so the religion of the Ugaritic Kingdom and the religion of the Canaanites must have been very similar. Cognate words in these languages that are embedded in similar contexts and are not used in an idiomatic expression should have virtually the same meanings. The ancient Israelites adopted the vocabulary of this region in their language.

Comments concerning whether etymology is useful are now addressed because I have seen some individuals come to unwarranted conclusions from the application of etymology. The supposed first or early use of a word is its etymology. On page 148 of his linguistic discussion, Peter Cotterell wrote, “The myth of point meaning. The first is *the myth of point meaning* - the

supposition that even if a word has a range of possible meanings attested in the dictionary, there lies behind them all a single 'basic' meaning." Then on page 149 he wrote, "The etymological fallacy. The myth of point meaning is closely related to *the etymological fallacy*. Words represent dynamic phenomena, their possible range of associated referents constantly changing, and changing unpredictably." On page 150 he wrote, "Thus, the meaning of a word will not be revealed by consideration of its etymology but by a consideration of all possible meanings of that word known to have been available at the time the word was used (thus avoiding the diachronic fallacy [the meaning may change over time]), and of the text, cotext, and context within which it appears. Even then it is necessary to be aware that an individual source may make use of any available symbol in any arbitrary manner provided only that the meaning would be reasonably transparent to *the intended receivers*." Later on this page the author continues, "The fact is that the etymology of a word *may* help to suggest a possible meaning in a particular text. But it is the context that is determinative and not the etymology." Even comparative Semitic cognates are useless if the contexts of the cognates are not the same.

The KJV was published in England in 1611 at a time after that nation had rejected the authority of the Roman Catholic Church and replaced it with its national church, the Anglican Church. However, there was some religious tolerance in England, especially for the Jews. Gesenius wrote his famous Hebrew lexicon before the middle of the nineteenth century, and he often used the meanings of ancient Arabic, Aramaic, and Syriac words to explain some Hebrew words. Thus Gesenius employed Semitic cognates to help understand biblical Hebrew, yet he did so in a responsible manner of matching the context. But after his death newer archaeological discoveries written in ancient Akkadian, Ugaritic, Phoenician, and Punic have been made, and thus many useful papers, lexicons, and commentaries have been written since the middle of the twentieth century that help explain certain Hebrew words and phrases. This is called the use of comparative Semitic languages applied to biblical Hebrew.

The Hebrew Scriptures were written over a period of hundreds of years in an ancient culture. The reader who wishes to study the Scriptures in solitary confinement with nothing but an English translation of the Bible will be disappointed because some of the Hebrew words are only now being capable of comprehension in its original context through archaeology, history, comparative Semitic languages, etc. There is no single source to acquire that

will provide all data that one needs to fully understand the latest attainable knowledge about ancient Hebrew. Strong's concordance is outdated in the scholarship of its lexicons, which were prepared by volunteer students. Many of its etymologies are conjectural and misleading. Etymology itself, even if correct, is often not a reasonable guide to discover the meaning of a Hebrew word. In general, etymology, especially when it is often a guess, is not a good method to use to arrive at the meaning of a Hebrew word that is not easily attained from its biblical contexts.

When journal articles discuss the meaning of a Hebrew word, they never refer to the Hebrew lexicon at the back of Strong's concordance because its lack of authority and care is well recognized in scholarly circles. The claims in Strong's concordance that word xxxx was etymologically derived from word yyyy are generally mere conjecture and should not be repeated. The only time I ever look at the lexicons at the back of Strong's concordance is to check that another writer has correctly quoted from it. But the word numbers in Strong's concordance are a very useful method for identifying the words for English speaking people for whom this is being written. Most Hebrew words do have stems, which are from two to four letters within the word.

I will provide literal translations of many Scriptures. For some significant words I will supply the Strong's number and often provide a transliteration of the Hebrew word in its standard singular form (for non-verbs) or its infinitive form (for verbs). Sometimes I will put the Strong's number and the transliteration in square brackets. Authors, editors, and other sources that are used are cited in full in the bibliography at the end. The English letter spellings that are used within Strong's concordance to transliterate the Hebrew words are most often contrary to all of the three Jewish schools of pronunciation (Ashkenazic, Sephardic, and Yemenite). Hence I will not use the spellings in Strong's concordance.

[4] Disguised Confusing Footnote in the Brown-Driver-Briggs Lexicon

The original BDB Hebrew lexicon was first published in 1907 by Oxford University Press. In 1979 this was reprinted by Hendrickson Publishers, who added Strong's numbers to the Hebrew words, but kept the text and the page numbers the same. The 1979 edition also added a useful appendix with Strong's numbers at the end. Long after this lexicon was completed in 1907, some important discoveries about some biblical Hebrew words have been made utilizing comparative Semitic languages, especially derived from

excavations of Ugaritic writings north of Israel and the Dead Sea Scrolls south of Jerusalem. These discoveries affect the meanings of some Hebrew words. Nevertheless, for most words BDB remains an especially complete and useful reference work.

Sometime after the original 1907 edition was printed, the original publisher added a final chapter on pages 1119-1127 titled, “Addenda et Corrigenda”, which is a list of further notes and corrections. When Hendrickson Publishers decided to reprint BDB in 1979, instead of leaving this final chapter at the end, they took each entry and **attempted** to place it as a footnote on the same page as the word to which it adds or corrects. Unfortunately, in some rare instances, the added note from the final chapter was too long to fully fit as a footnote on the same page as the original word, so that it was continued onto the next page without a clear warning near the bottom of the continuation page. This has deceived some sincere people on the continuation page for a critical Hebrew word concerning the calendar.

The Hebrew word *chodesh*, having Strong’s number 2320, is discussed on pages 294-295 of BDB, and is given the translation “new moon” or “month”. At the bottom of page 294 there is a difference between all printings from Oxford University Press compared to the 1979 edition. The 1979 edition has four extra lines at the bottom of the page, and some people have been led astray by not realizing that these four lines are the continuation of a footnote from the bottom of page 293 for the Hebrew verb *chadar*, having Strong’s number 2314. Therefore, these four lines have nothing to do with *chodesh*, and they appear as a disguised confusing footnote. Part of this footnote says, “conceal behind curtain, conceal, confine”, and this gives the false impression that *chodesh* refers to the condition of the moon when it cannot be seen. In the chapter of “Addenda et Corrigenda” in the later reprints by Oxford University Press, this long note for *chadar* appears in the middle of column 1 on page 1123 where it specifies that it refers to the Hebrew word *chadar* from page 293. BDB makes no implication at all concerning the appearance of the moon at the “new moon”. The new moon will be discussed below where it seems most appropriate.

[5] Introduction to Ancient Calendars and Ancient Astronomy

In modern times much has been discovered about ancient calendars generally, especially with the help of applying the computer and astronomy

software to ancient records in order to sift out conjecture from fact. During the 20th century many volumes of ancient astronomical records were translated and published. These have been studied in detail, and an improved history of ancient mathematical astronomy has been erected, especially since the Akkadian language of Assyria and of the priests of Babylonia was first deciphered in the late 1800's and archaeological discoveries were translated. It is unfortunate that such information is not readily available in every small-town library or on the Internet without cost. Recent research is copyrighted and may not be legally reproduced on the Internet for free or without permission. Thus the person who desires to study such matters today is very greatly handicapped by either living far away from research libraries, or even when only 50 miles away, a major effort must be made to fight one's way through congested traffic many times over a period of years to become familiar with the available literature. Sometimes an innocent unsuspecting person may come to a premature conclusion about the biblical calendar and then writes with conviction, thus leading other innocent ones into conclusions that would not stand up among learned people. Other people are not so innocent because they have a bias against all ideas contrary to the modern calculated Jewish calendar. Such bias often leads those to throw dust and smoke into the air and attempt to cause confusion among others who really seek genuine biblical understanding.

Since the calendar is linked to the astronomy of the sun, earth, and moon, it is important to discuss this early to define certain technical terms and to ensure that irrational and erroneous thoughts about astronomy are avoided.

[6] Ellipses and Orbits of Heavenly Bodies

The path that one heavenly body takes as it goes around another heavenly body is called its orbit. Ancient peoples did not know that the planets orbited the sun. Instead they thought that all the heavenly bodies circled around the earth. There was only one ancient Greek astronomer who went against his contemporaries by espousing his theory that the "wandering stars and the earth" (the planets) circled the sun, namely Aristarchus of Samos c. 280 BCE (see pages 74-75 of Toomer 1996). The only other ancient astronomer who is known to have accepted this sun-centered viewpoint is Seleucus of Babylon c. 150 BCE (see page 391 of Pedersen and page 247 of Stahl).

When discussing history, it is always best to quote from the original historical sources or translations of them (these are called primary sources),

and then arrive at conclusions. Unfortunately, when the history of ancient astronomy is the topic, problems are encountered that prohibit quoting from original sources before Ptolemy (c. 150 CE). One insurmountable problem is that the important ancient astronomical texts are not written for the purpose of teaching others their methods; there are no ancient textbooks. Instead we find columns or tables of numbers with some occasional notes, and there are records of observations with some notes. The ingenuity of modern historians of mathematics and astronomy has enabled them to determine the meanings of the various columns and the meanings of the scientific terms used. Modern science has reverse engineered the ancient texts to learn what must have been their ancient methods in order for the columns of numbers and the occasional notes to make sense. While English translations of ancient astronomical texts certainly exist, there would be no benefit to quote from any one text for an understanding of the underlying methods unless one were writing a detailed textbook which required some significant knowledge of mathematics and astronomy. This difficulty in not being able to quote from the primary sources pertaining to ancient astronomy for the layman makes it necessary to quote and cite modern secondary sources.

For the history of astronomy the original ancient sources are so obscure that a correct interpretation requires great care by specialists in this field, so that scholars who are only historians or only modern astronomers may easily go astray in their conclusions. A generic example of the obscurity is a writing tablet with orderly columns of numbers having some symbol at the top of each column and some miscellaneous remarks. First, one translates the numbers into today's numbers, and also translates the miscellaneous remarks. Second, one determines patterns to the numbers and relates these patterns to known values relating to astronomical time periods of heavenly bodies. Some columns become reasonably easy to interpret or explain, while other columns may remain a matter of modern scholarly debate for 100 years or more because the tablets themselves do not define the meaning of the columns. Simply publishing a literal translation of the tablet does not do the layman any good at all.

Because of this, when some scholar publishes a paper about the history of ancient astronomy, it may require some years of scholarly debate in order that a clear mutual understanding of the correctness of that paper will emerge. During the twentieth century some papers were published in this subject that were subsequently proven false by the best scholars in this field. But less knowledgeable writers on the history of science thought that some

of these papers were correct before they were proven false, and thus popular published articles, Internet website articles, and books on the history of ancient astronomy are available with information that modern specialists in this field know to be false. Unless a person devotes some years of study to the literature on this subject and keeps up with the latest journals and advanced books related to the history of ancient astronomy, it is easy to be led astray. I have performed Internet searches and have been greatly dismayed at the widespread misinformation available. I have taken great care to learn who the best authorities are in this field, and I have only used internationally respected specialists for my quotations and sources. I have kept up with the latest literature for the specific details that are especially significant for this study.

Educated people of today know that the earth rotates on its axis once each 24-hour day, but we still speak of the sun rising up in the morning rather than the earth rotating to enable us to see the sun. Thus the sun does not really move fast around the earth so as to truly rise in the morning, but the expressions in our language, which have been handed down to us since ancient times have remained. The NKJV states in Eccl 1:5, “The sun also rises, and the sun goes down, And hastens to the place where it arose”. Nothing is improper here by saying what appears to happen from the perspective of an observer on earth. Gen 1:14 mentions the dividing of the daytime from the night, and it says that the lights in the heavens have this purpose. We must not be critical of the Bible here on the grounds that the rotation of the earth on its axis would be explained as the cause today. Regardless of the physics, the Bible was written in terms of human perception from the surface of the earth and must be accepted this way.

The Bible gives no hint of advanced mathematical or astronomical knowledge from the days of Moses. Ancient people thought that the sun went around the earth in an orbit having the shape of a circle, and that the moon went around the earth in an orbit having the shape of a circle. Ancient Greek astronomers used the mathematics of circles to approximate the predictions of eclipses and other astronomical events, but they had to add some complexity to their mathematical schemes because they eventually discovered that the speed of the moon around the earth was not constant. They modified their mathematics in an attempt to make their predictions agree with what they observed later, yet they continued to accept circular motion of the heavenly bodies.

The German astronomer Johannes Kepler (1571-1630) discovered that the orbit of Mars around the sun had the shape of an ellipse. Sir Isaac Newton (1642-1727) proved that all planets of our solar system had an orbit around the sun shaped as an ellipse. Ancient predictions could never become extremely accurate compared to what was achieved by Newton because ancient astronomers did not truly understand the laws of motion, the shape of orbits, the physical reality of what was primarily moving, and the higher mathematics needed to prove the more precise physical relationships through time. Kepler was innovative and brilliant in using geometry to derive his results about Mars, but without having the calculus that Newton was the first to apply to astronomy, Kepler was greatly handicapped to go beyond his great achievements. But Kepler had at his disposal the very carefully documented results of many years of fine observations by Tycho Brahe, who used accurate carefully constructed mechanical astronomical instruments, and Brahe was funded by willing donors who were not concerned that the effort was not useful to people at that time. Kepler stood upon the shoulders of Brahe. Newton said that his achievements were only possible because he stood upon the shoulders of giants. The inventions of the telescope and the pendulum clock were a great help to astronomers who gave accurate data to Newton. The invention of the printing press helped to spread scientific achievements far and wide so that brilliant minds in diverse places could rapidly feed upon each other's results. The funding of European universities and the exchange of knowledge among people in a variety of scientific disciplines that was characteristic of the renaissance helped to make this achievement possible. The ancient world lacked such a critical mass of diverse inventions and published scientific papers that teamed together to enable such magnificent results. A key word of this paragraph is *ellipse*. A few remarks about the nature of an ellipse may be useful in order for the reader to appreciate certain later comments concerning the moon's orbit around the earth. If the reader does not understand some of the discussion in the next few paragraphs, it is of no great consequence.

Picture a circular white pancake resting on a dark tabletop and consider looking at it from directly above. Its boundary looks like a circle. Then picture yourself standing upright on the floor a short distance from the table while looking at the pancake. If the height of the table is only the size of your big toe, the boundary of the pancake will look very much like a circle, but if the height of the table is only a little below the height of your eyes, the boundary will look like a very squashed circle. At some in between height, the boundary will look somewhat like an egg. Each boundary shape of the

circular pancake viewed from a very low height to one near the height of your eyes is technically called an ellipse in mathematical terminology.

The orbit of the earth around the sun is nearly a perfect ellipse that is somewhat close to being a circle. The orbit of the moon around the earth is nearly a perfect ellipse that is a little less circular. If the moon and the planets did not have gravitational relationship with the earth, then the earth's orbit would be as perfect an ellipse as one could expect for a physical object. If the sun and the planets away from the earth did not attract the moon, then the moon's orbit around the earth would be a nearly perfect ellipse. However, in a technical sense the last sentence is not quite true because if the sun continues to pull at the earth and would no longer pull on the moon, the moon would fly off away from the earth because the annual orbit of the moon around the sun is based on the sun's pull on the moon, not the earth's pull on the moon.

The position of the sun within the earth's orbital ellipse and the position of the earth within the moon's orbital ellipse are not at the center where one might expect. The following will explain where they are. Picture a straight stick nailed to the center of an ellipse, and picture the length of the stick to only extend from one edge of the ellipse to the other. Now imagine hitting the stick so that it spins around the ellipse, but imagine the length of the stick stretching and shrinking as it turns, so that it always only extends from one edge of the ellipse to the other. The major axis of the ellipse is the stick's line segment when it is longest in its spin, and the minor axis of the ellipse is the stick's line segment when it is shortest in its spin. These axes are perpendicular to one another and cross at the center of the ellipse.

Picture a stick in the position of the major axis, but imagine it to be broken at the center of the ellipse with its two halves loosely glued together so that it may change angle where the glue holds them. Now imagine putting the palm of each of your hands at the ends of the stick and slowly pushing them together as when beginning to clap hands. The clapping movement should be toward the center of the ellipse so that as both hands move at the same speed, the stick rests in the plane of the ellipse, and the glued spot moves up the minor axis. Stop the movement when the glue touches one end of the minor axis. The two ends of the stick at your palms lie along the major axis, and the two halves of the stick are joined at one end of the minor axis. Now each end at a palm is at a point called a focus of the ellipse. Each ellipse has two foci, both of which are on the major axis and off the minor axis. The

procedure described shows that the distance from each focus to an end of the minor axis equals half the length of the major axis. There is only one point on an ellipse closest to a focus; that is the nearer of the two points at the ends of the major axis. Similarly, there is only one point on an ellipse furthest from a focus; that is the further of the two points at the ends of the major axis.

The sun is at a focus of the earth's orbital ellipse. The earth is at a focus of the moon's orbital ellipse. Thus the sun is never at the center of the earth's orbit and the earth is never at the center of the moon's orbit.

[7] Astronomical New Moon (Conjunction) and Full Moon

From the viewpoint of an observer on the earth far away from the north and south poles, the moon has periodically changing appearances. Typical appearances of the moon's cycle may be described as (1) the widening crescent, (2) the moon increasing toward full circle, (3) the full circle, (4) the moon decreasing away from full circle, (5) the narrowing crescent, and (6) invisibility. The **astronomical new moon** (as recognized by modern astronomers) is the moment in time (or the moon's position) in each cycle of the moon around the earth at which the center of the moon is closest to the straight line between the sun and the earth. The astronomical new moon is also called the **conjunction** of the sun and the moon as observed from a person on the surface of the earth.

A **solar eclipse** is the covering of the sun by the moon as seen by an observer on the earth when the moon comes between the sun and the earth. Such an eclipse is called **total eclipse** when the circle of the moon lies inside the circle of the sun. A solar eclipse can only occur during the time of the conjunction. How dark is it during a solar eclipse, and how long does a solar eclipse last? On pages 198-199 of Zirker we read, "During a total eclipse, however, the corona [the sun's disk] is only as bright as the full moon." On page 30 we read, "The maximum diameter difference is 2'38" and the maximum duration of totality is 7 minutes and 40 seconds for an observer near the equator. The 1973 eclipse in West Africa came very close to this maximum theoretical totality. On the average, a total eclipse only lasts for two or three minutes and seems much shorter."

Chapter 12 of Zirker's book is titled "The Great Hawaiian Eclipse" where Zirker describes the famous total eclipse over the Hawaiian Islands on July

11, 1991, which is significant because of the world famous observatory on Mauna Kea at 13,700 feet above sea level, which provided superb scientific facilities for observation. This total eclipse lasted 4 minutes 11 seconds (page 197). Page 197 states, "Schoolchildren [on Hawaii] were equipped with dark slides to view the eclipse and preparations were made to bus them to favorable locations." The reason that they look through special dark slides is so that their eyes are not damaged due to the harmful rays of the sun. During the 4 minutes 11 seconds of totality of the solar eclipse, one's eyes should not be damaged because the brightness is near that of the full moon, but outside that narrow window of time, one's eyes surely will be damaged when the moon only partially blocks the sun.

The following definitions are relative to a place on the earth significantly away from the north and south poles. The **crescent period** of the moon's cycle is the time after the three-quarter-size moon and before the following one-quarter-size moon excluding the time during which the moon is invisible and the time at which there may be a solar eclipse. The moon is called a crescent during the crescent period. The **old crescent** is the moon during the time that it is visible, assuming the atmosphere is clear, on the last day that it is visible prior to the astronomical new moon. The old crescent is seen looking east in the morning. The **new crescent** is the moon during the time that it is visible, assuming the atmosphere is clear, on the first day that it is visible after the astronomical new moon. The new crescent is seen looking west in the evening. The new crescent is sometimes called a young crescent.

Bartel Leendert van der Waerden (1903-1996) was an internationally prominent scholar in the fields of mathematics and the history of ancient astronomy. On page 169 of van der Waerden, he wrote: "The difference between the first days of an exact month [month starting with and ending with the conjunction] and an observed lunar month [month starting with and ending with the new crescent] is one or two days, or in exceptional cases three days."

On page 66 of Beaulieu we find, "In ancient Babylonia the day was reckoned from one sunset to the next. The monthly count was based on lunar phases, with the month beginning after sunset when the new crescent of the moon was seen again in the western horizon. This happened at the earliest one day, and at the latest three days after conjunction."

At the end of the above sentence is “2” (footnote) which states the following (same page, square bracket comments are in the journal, not from me), “That the moon never disappeared for more than three days following conjunction was evidently known to Assyrian and Babylonian astronomers, as shown in H. Hunger, *Astrological Reports to Assyrian Kings* (SAA 8, 1992), text 346, a report sent by the scholar Asaredu the younger: ‘On this 30th day [the moon became visible]. The lord of kings will say: “Is [the sign?] not affected?” The moon disappeared on the 27th; the 28th and the 29th it stayed inside the sky, and was seen on the 30th; when else should it have been seen? It should stay in the sky less than 4 days, it never stayed 4 days.’”

On page 87 Beaulieu wrote: “Even after the 6th century B.C., when Babylonian astronomers developed the mathematical schemes which enabled them to calculate month-lengths in advance, it is probable that observation remained the sole authoritative way of fixing the beginning of the month.” Page 244 of Britton 1999 indicates that the Babylonian method for predicting the sighting of the new crescent is likely to have originated within the years 457-419 BCE. The Babylonian calculation for the sighting of the new crescent is based upon approximate repeating sequences of data over long periods of time. Existing records of some of the data that are used in these patterns go back to 568 BCE, which is 18 years after Solomon's temple was destroyed in 586 BCE, and the earliest archaeological source that has all astronomical parameters that are needed for the prediction of the sighting of the new crescent is dated 373 BCE (see page 197 of Hunger and Pingree). Thus the time at which the Babylonians developed methods to approximately determine the day of the new crescent is about 450 BCE. Perhaps about 400 BCE their method was actively being used. I have not seen any published papers that attempt to quantify how accurately the Babylonian methods predicted the new crescent.

Based upon data showing that one factor of considerable significance to the Babylonians is predicting the time from when the sun sets below the western horizon to the time when the moon sets below the western horizon during the crescent phase (although other time based factors were also sought by the Babylonians), and knowing that this method has some degree of reliability toward predicting the visibility of the new crescent (but is far from a perfect method), my estimated guess is that their predictions for the new crescent were correct between 80 and 85 percent of the time when the weather was clear.

Today we speak of the conjunction and we define it in terms of the three dimensional geometry of the sun-earth-moon system and the language of orbits. But ancient people did not have our modern concept of a sun centered solar system (except for two known ancient astronomers who were ridiculed), and to the best of our knowledge today, ancient people did not have our three dimensional model of the sun-earth-moon system. We must realize that the ancient concept of the conjunction and our modern concept are different. They could see a solar eclipse, and whenever there was a solar eclipse, there was necessarily a conjunction also. But that was the only kind of conjunction they could see. What concept could they have for the conjunction generally if they could not see it? Page 110 of Koch-Westenholz states, "The Babylonians seem never to have given an astronomical explanation of eclipses." Page 101 of Koch-Westenholz states, "I know of no Babylonian astronomical explanation of the phases of the moon, ..." The Babylonians did notice the obvious fact that when the full moon occurs the moon and sun are at opposite ends of the sky, and during the symmetrically opposite time of the lunar cycle the moon and sun are traveling along side by side. A translation of an ancient Babylonian text that discusses the moon's cycle of disappearance is on page 101 of Koch-Westenholz, where "you" refers to the moon: "On the day of disappearance, approach the path of the sun so that [on the thirtieth day (?)], you shall be in conjunction, you shall be the sun's companion." Here the author's translation "conjunction" does not require that it refer to an instant in time. It is merely the time that the sun and moon are companions, traveling together.

With clear weather the Babylonians knew there could be one, two, or three nights of invisibility of the moon (as mentioned above from van der Waerden and from Beaulieu). At the moment of true conjunction the moon and sun can be at most 5.2 degrees apart from a point on the earth's surface. At this narrow an angle if the sun is in view or very near the horizon, the light from the sun will be too brilliant for the moon to be seen directly or even indirectly (the latter is called earthshine). **Earthshine** is the light from the sun to the earth, which then reflects back to the moon and then reflects to the observer on earth. Thus earthshine is the light seen from a double reflection. It is usually easy to see earthshine as the completion of the moon's circle as a faint grayish blue with the crescent at one edge on the second day old crescent. Often earthshine may be seen on the day of the new crescent if it is not a very narrow crescent. Neither modern nor ancient people could see earthshine at the time of conjunction because the sun's

brilliance is too close to the moon, and this has nothing to do with air pollution.

When the conjunction occurs, the moon is invisible except during a rare solar eclipse when the moon covers the sun from view from observers in a certain region on the earth for at most 7 minutes and 40 seconds (see the quote from Zirker above). Without knowledgeable calculations, it is not possible to accurately determine the time of the conjunction. Because the conjunction is not visible except during a rare solar eclipse, ancient people who did manage to arrive at some mental concept of the conjunction (such as the time period when the sun and moon are traveling together) and who also desired to achieve a mathematical computation to predict the time of the conjunction, would only be able to check the accuracy of their mathematical prediction during the rare occasion of a solar eclipse where they were located. The strong desire of certain ancient peoples, specifically the Chinese, the Babylonians, and the Greeks, to be able to predict solar eclipses, along with a knowledge of the mathematics that enabled them to make this approximation led to their interest in the conjunction as the approximate time when the sun and moon were traveling together.

Historical records of eclipses over a long period of time will suggest cycles of repetition of eclipses, and this may be simply described as a “bookkeeping” method to predict eclipses. In the book on ancient eclipse predictions by John Steele 2000, he discusses Chinese eclipse predictions on pages 175-215. On page 177 in the context of China, Steele wrote, “Although there are many steps in this process – and many potential places for mistakes – it has the advantage that eclipse prediction is reduced merely to bookkeeping, and yet the method still predicts most visible eclipses over the course of a hundred years or so. Furthermore, the calendar tends to predict too many, rather than too few, eclipses.” Later on this page we find, “The first mathematical treatment of eclipse calculation [in China] without reference to an eclipse cycle is found in the *Ch’ing-ch’u-li* from the third century AD.” Steele’s description of these methods reveals a computation to repeat an eclipse rather than a mathematical geometrical model of where the heavenly bodies will be in the future. The purpose of including this piece of history is to remove some of the exotic imagined ideas that some laymen possess concerning the abilities of ancient peoples.

The **full moon** is the moment in time (or the moon's position) in each cycle of the moon around the earth in which the center of the earth is closest to the

straight line between the sun and moon. The full moon is also called the **opposition**. When the full moon occurs, it looks like a full circle. However, the time of the moon's appearance as a full circle lasts at least two nights and it looks quite circular for several nights, so without knowledgeable calculations, it is not possible to accurately determine the time of the full moon by observing the circularity of the moon. On the other hand, it is possible to use a different observational method to make a judgment of the day after the moment of full moon as follows. During the several days near the time of the full moon the following two statements are true. Before the moment of the full moon, the moon rises in the east before the sun sets in the west. After the moment of the full moon, the moon rises in the east after the sun sets in the west. Using these principles one can use the rule that the first evening in which the moon rises in the east after the sun sets in the west begins the day after the moment of the full moon. One drawback of using this observational method is that it requires a straight horizontal unobstructed view of both the eastern horizon and the western horizon, and both of these horizons must be at the same altitude above sea level. Hills and trees will hinder accuracy. Besides this, if two observers perform this activity from different locations that have opposing horizons, which differ in their altitude above sea level, it is possible that their conclusions will differ in a near borderline case.

[8] Variation from Astronomical New Moon to Full Moon; Variation from New Crescent to Full Moon

Someone may imagine that since the day immediately following the moment of the full moon could be known by the method described above, perhaps the day of the conjunction could be known from the day of the full moon. This conjecture is now discussed.

On the bottom of page 6 of Parker 1950, he wrote, "The necessary time for full moon varies from 13.73 to 15.80 days after conjunction." This is a swing of 2.07 days, which is about 49 hours 41 minutes. This shows that the conjunction (i.e., astronomical new moon) does not have to be exactly opposite the full moon.

By examining a few cases near these extremes in the 20th century we may compare the day of the lunar month based upon whether one considers the first day of the lunar month to be the day on which the conjunction occurs or

the day on which the new crescent is seen. Let us consider three cases in which the computation for visibility of the new crescent is made from Jerusalem, and the boundary for a new day is computed as sunset. For those who wish to check with other software, I am considering the latitude of Jerusalem to be 31.80 N and the longitude of Jerusalem to be 35.22 E, which are the coordinates I have seen for an official weather station of Jerusalem. The abbreviation **UT** stands for “universal time”, and is intended to refer to the time zone based upon Greenwich, England.

Case 1: Conjunction on July 7, 1967 at 17:01 UT and sunset 16:48 UT

The full moon occurred on July 21, 1967 at 14:39 UT. The time from conjunction to full moon is 13.90 days (a little over the minimum of 13.73).

Note that the conjunction occurred shortly after sunset, close to the beginning of a new day. For a month that is considered to begin on the day of the conjunction, the full moon occurs on the 14th day of the month in this example.

On the evening that ends July 9, 1967 the new crescent will be theoretically visible. For a month that is considered to begin on the day beginning with the new crescent, the full moon occurs on the 12th day of the month.

Case 2: Conjunction on December 12, 1966 at 3:15 UT and sunset 14:35 UT

The full moon occurred on December 27, 1966 at 17:45 UT. The time from conjunction to full moon is 15.60 days (a little under the maximum of 15.80 days). For a month that is considered to begin on the day of the conjunction, the full moon occurs on the 15th day of the month in this example.

On the evening that ends December 13, 1966 the new crescent will be theoretically visible. For a month that is considered to begin on the day beginning with the new crescent, the full moon occurs on the 13th day of the month.

Case 3: Conjunction on September 26, 1973 at 13:54 UT and sunset 15:32 UT

The full moon occurred on October 12, 1973 at 3:11 UT. Note that the conjunction occurred shortly before sunset, close to the end of a new day.

The time from conjunction to full moon is 15.55 days (a little under the maximum of 15.80 days). For a month that is considered to begin on the day of the conjunction, the full moon occurs on the 17th day of the month in this example!!

On the evening that ends September 28, 1973 the new crescent will be theoretically visible. For a month that is considered to begin on the day beginning with the new crescent, the full moon occurs on the 14th day of the month.

Conclusion from these Examples

In these examples, for a conjunction month, the full moon occurs from the 14th to the 17th day of the month. The 17th is very rare.

In these examples, for a new crescent month, the full moon occurs from the 12th to the 14th day of the month. In the most extreme case for a new crescent month, the full moon can occur on the 16th day of the month, but this is very rare. Typically the full moon occurs on the 13th, 14th, and 15th for the new crescent month.

[9] Ancient Meaning of the Full Moon

What did the full moon mean to the ordinary person in ancient times? We have one example of what it meant to the Jewish philosopher Philo who lived in Alexandria, Egypt and who wrote in the early first century. On page 17 of Philo_QE (section 9), in a context concerning Passover, Philo wrote, "For when it [the moon] has become full on the fourteenth (day), it becomes full of light in the perception of the people." On page 401 of Philo_7 (Special Laws 2:155), in a context concerning the seventh month, Philo wrote, "The feast begins at the middle of the month, on the fifteenth day, when the moon is full, a day purposely chosen because then there is no darkness, but everything is continuously lighted up as the sun shines from morning to evening and the moon from evening to morning and while the stars give place to each other no shadow is cast upon their brightness." We see here that Philo considers both the 14th and the 15th days of the month to be days of the full moon. Hence he does not consider the full moon to be an instant in time or only one day of the month, but a general period when the moon is quite circular. As an ordinary person he did not adopt the meaning for the full moon of advanced Greek astronomers as a mathematically

predicted moment when a lunar eclipse would sometimes occur. Due to the elliptical orbit of the moon, this mathematical moment will vary by a few days in relation to the conjunction, and it will also vary by a few days in relation to the new crescent. The precision of mathematics was not Philo's approach to the meaning of the full moon.

Although Philo, a Jew who lived in Alexandria, Egypt, is a historical first century witness that the moon is full on the 14th and 15th days of the Jewish months, this is not a biblical argument that a biblical month is full on the 14th and 15th days of the month.

In the early first century Vitruvius wrote the views of the Greek astronomer and mathematician Aristarchus of Samos (c. 280 BCE) concerning the full moon. On page 264 Vitruvius wrote, "On the fourteenth day, being diametrically across the whole extent of the firmament from the sun, she is at her full and rises when the sun is setting." This is approximately the rule given above, namely the first evening in which the moon rises in the east after the sun sets in the west begins the day after the moment of the full moon. However, Philo of Alexandria took a looser concept of the full moon allowing both the 14th and 15th days of the month to be days of the full moon.

[10] When in History did Prediction of the Astronomical New Moon Begin?

The history of ancient astronomy shows that it was not until near the time of the birth of Alexander the Great that ancient astronomers were first able to estimate the time of the conjunction of the moon by a calculation.

On page 169 of van der Waerden, he wrote:

"In Babylonia, the month began on the evening on which the crescent was visible for the first time after [the astronomical] New Moon. More precisely: If on the [ending] evening of the 29th day of any month the crescent was visible, the month has 29 days; if not, the month has 30 days. The same rule still holds in Muslim countries."

"I shall call these months 'observed lunar months'. The words of Geminus indicate that the Greek months originally were just observed lunar months."

"The months beginning with the conjunction will be called 'exact lunar months' or 'conjunction months'. These months are a theoretical construction; they could not be used in practice in classical times, because

before Kallippos [Callippos] (330 B.C.) astronomers were not able to predict the true conjunction.”

Thus van der Waerden points to 330 BCE as the time before which ancient mathematical astronomical knowledge was not able to predict the time of the astronomical new moon.

The orbit of the moon around the earth is an ellipse. The earth is not at the center of this ellipse, but at one of the two foci of the ellipse. The moon moves faster around the earth when it is closer to the earth than when it is farther from the earth. Due to the sun's gravitational attraction to the earth and moon, the distance from the earth to the sun affects the distance from the moon to the earth, which in turn affects the time from conjunction to conjunction! The exact time from conjunction to conjunction does vary through the year! Knowing the average time from conjunction to conjunction does not help to know any current lunar month's time from conjunction to conjunction.

The minimum time from one conjunction to the next conjunction is 13 hours 40 minutes less than the maximum time from one conjunction to the next conjunction (see pages 21-22 in Stephenson and Baolin). A mathematical mastery of this variation is needed in order to accurately predict the time of an astronomical new moon.

A high level of confidence of the accurate prediction of solar eclipses by ancient peoples was certainly impossible because this requires a knowledge of where the moon's shadow will reach the earth, and that requires a knowledge of the distance from the moon to the earth (which requires a knowledge of the elliptical orbit of the moon), the size of the earth, and the shape of the earth (which is somewhat pear-shaped rather than perfectly spherical). Since they could not predict the shadow path of the moon upon the earth, the best they could achieve is a statement that a solar eclipse was a reasonable possibility. But in order to do that, they would need to have a good ability to predict the astronomical new moon as well as how to rule out most astronomical new moons as being capable of providing a solar eclipse. This simply shows that we can judge the ability of ancient astronomers to approximately predict the astronomical new moon by their attempts to predict a possible solar eclipse.

Of specific interest is the paper by John M. Steele 1997 where, on page 134 he lists the oldest Babylonian solar eclipse prediction for which we have full data in 358 BCE, exactly 100 years after Ezra first brought a group from the House of Judah back to Jerusalem after the Babylonian captivity. This solar eclipse prediction was 181 years after King Cyrus the Great of Persia conquered Babylon on October 12, 539 BCE (see page 14 of Parker and Dubberstein). Since the empire was now the Persian Empire rather than the Babylonian Empire, the learned astronomers who continued their work should be called Persians, but the general practice is to continue referring to them as Babylonian or “late Babylonian”. The same pagan priests continued to improve their work in mathematical astronomy. John Steele 1997 analyzes the 61 preserved solar eclipse predictions of the Babylonians for which full data is available including the time at which the eclipse is hoped to be seen, and these fall within the years 358 BCE - 37 CE. The terminology used by the Babylonians shows that a solar eclipse was to be “watched for”, showing an uncertainty that it would be seen. Less than half (28 of 61) were either seen or would have been seen if the precise time of the eclipse would have occurred during daytime in the region of Babylon. In other words, in these 28 cases the latitude of the moon's shadow did fall within some part of greater Babylon, but in the other 33 cases the moon's shadow was outside this region. These ancient astronomers used water clocks, which divided the day into 360 equal parts, each being four minutes. The average error of these water clocks is eight minutes from true time. The predictions included the calculated time for the eclipse to occur. The worst two predictions among these 28 cases were 8.08 hours in error and 4.76 hours in error (page 135). The average error was 1.96 hours (page 136). For the other 33 cases of predictions the average error in the time of conjunction (here the word “conjunction” relates to a hoped for solar eclipse) is 3.67 hours, nearly twice as great (page 137)! Their predictions of solar eclipses did not get more accurate in the later period of their recordings (pages 138-139).

The mathematical methods that were used by the Babylonians were very different from the methods used by the Greeks. The former used nearly repeating sequences based on prior historical records (not a formula based on a general physical mathematical model), while the latter developed a geometrical mathematical model based on circles after 400 BCE. The Greeks were aware of the methods used by the Babylonians (see page 118 of Jones, the chapter by Toomer 1988, and page 61 of Fatoohi and others), but the most advanced Greek astronomers preferred their own methods. The

methods of the Greeks were more advanced in the sense that they were based on mathematical methods for approximate geometrical models, and the geometry itself led to the concept of the conjunction. In contrast to this, the Babylonians were interested in predicting solar eclipses, which by definition only occur at the time of a conjunction; they did not show a general interest in predicting the time of all conjunctions, and this was likely the cause for van der Waerden's limiting of the year for calculating the approximate astronomical new moon (conjunction) to 330 BCE. On page 41 of Aaboe we read, "Babylonian mathematical astronomy has two features that seem strange to modern eyes, and it may thus be in order to mention them here. First, it is entirely arithmetical in character or, in negative terms, there is no trace of geometrical models like the ones we have become accustomed to since the time of Eudoxos [Greek astronomer of Cnidos, c. 408 to 355 BCE (see pages 63-66, 335 of Pedersen)]. Second, the cuneiform literature [clay tablets bearing the Akkadian language of the Assyrians and a remnant of the Babylonians] nowhere attempts to justify the precepts of the procedure texts; thus it has rested with modern scholars to uncover the underlying theoretical structures." In other words, the Babylonians have left us their many tablets showing columns of numbers, and it remained for modern scholars to decode the meaning of these columns and how they were computed. In some cases there are narratives that accompany these numbers that mention certain sighted phenomena in the heavens or some indications of the meanings of one or more columns, but there are no geometrical diagrams showing a mathematical model of anything in the heavens among the Babylonians.

The conclusion is that there are unusual aspects of the variation of the moon's cycle around the earth that prevented ancient people from predicting the approximate conjunction until about 330 BCE by the advanced methods of the Greeks, or instead, until about 360 BCE for the non-geometrical methods of the Babylonians whose average error was about three hours. Moreover, the Babylonians were focused on solar eclipses rather than conjunctions in general, while the Greeks showed an interest in conjunctions. Another very significant factor that contributed to the difficulty of predicting the conjunction is the lack of visual confirmation of a conjunction unless there was a rare solar eclipse to confirm it. The water clocks used by the ancient Babylonian astronomers had an average error of eight minutes and their smallest unit of measuring time was four minutes. Their predictions were long term, i.e., there is nothing to indicate that they attempted a revised prediction within days of a solar eclipse. When

conditions were not right for a solar eclipse they never predicted a “conjunction” because it would have been foolish to predict a phenomenon that was not potentially verifiable with an observation.

A ***lunar eclipse*** is the covering of the sun's light to the moon by the earth as seen by an observer on the earth when the earth comes between the sun and the moon. In sharp contrast to the special difficulties of predicting solar eclipses, there are no comparable problems in predicting lunar eclipses. Lunar eclipses must occur during the full moon, may be seen by nearly half of the people on the earth where the weather is not nasty (the side of the earth where it is night), are visible more frequently than solar eclipses from any one location, have calculations that may be tested from monthly approximate sightings of the full moon, and do not require predicting the path of a shadow (in this case, the shadow of the earth upon the moon). Hence there is a vast difference between the difficulty in predicting solar eclipses (some conjunctions) and the ease in predicting lunar eclipses (some full moons) by ancient astronomers. Page 3 of Britton 1989 states, “For a given location, therefore, lunar eclipses are seen nearly 4 times as frequently as solar eclipses.” But even when there is no lunar eclipse, the full moon is still visible. When there is no solar eclipse, the moon is not visible.

Ancient Babylonian astronomers were significantly more successful in their accuracy at predicting lunar eclipses than they were at predicting solar eclipses. Of specific interest is the paper by John M. Steele and F. Richard Stephenson. The oldest Babylonian lunar eclipse prediction for which we have full data is in 731 BCE (see page 125), which is 373 years before the first known reasonably accurate solar eclipse “hoped for” prediction by the Babylonians for which we have complete data! They were successful in their prediction for 731 BCE. Page 125 lists 35 Babylonian predictions of lunar eclipses for which we have complete data including the time of prediction to be observed. Also listed is the duration of time for which the eclipse was observed by the Babylonians, when it was successfully seen. These are dated from 731 to 77 BCE. Their average error for predicting the time of lunar eclipses was about one hour (page 130). In 90 percent of the predictions they were either successful or there was a near miss as defined by the authors (pages 123, 130). Their average error for lunar eclipse predictions was about one hour compared to about three hours for solar eclipses. It took about 400 years more for the Babylonian astronomers to be able to predict reasonably accurate possible solar eclipses (associated with the conjunction) than for them to be able to predict lunar eclipses (associated with the full moon).

There are numerous other dates of predictions of both lunar and possible solar eclipses by the Babylonians, but the time of day of their expected or hoped for sighting is not provided in the ancient sources. Without having the time of day of a predicted lunar eclipse or a possible solar eclipse it is impossible to judge the accuracy of the method of prediction, so it is not reliable to include such records in a discussion of known results. On the other hand, where columns of data are provided in a Babylonian text, it is possible for a modern specialist in this area of ancient science to judge whether the method is quite different from the more accurate later methods. In Britton 1989, John Britton evaluates the method used by the Babylonians for their earliest known attempt to predict possible solar eclipses. This text, which he called Text S, describes 38 solar eclipse possibilities from 475 to 457 BCE (see page 1 of Britton 1989). On page 44 Britton states, "We find in Text S an unusual mixture of disparate elements not known from other texts." After discussing the method used by these Babylonians, he wrote on page 46, "Indeed, with one exception the entire theory [for predicting possible solar eclipses] can be derived from counts of phenomena (lunar eclipses, eclipse possibilities, and months), and there is no evidence that measurements of times, angles or magnitudes played any role in its creation." From the data in Text S, Britton discusses its primary computation, which he calls "psi-star-of-S". His conclusion on page 46 is, "We see this best in the fact that psi-star-of-S, a function clearly derived from lunar eclipses and measuring the proximity to the node of the earth's shadow at conjunction (or the moon at mid-eclipse), is correctly applied to solar eclipse possibilities by simply moving the entire function forward half a month." A simplified way of saying this is that these Babylonians estimated the time of the conjunction to be the midpoint between two successive computed full moons, and then judged the confidence for a solar eclipse based on the history of repeating eclipses. But we have seen above that it is very crude to estimate the conjunction to be the midpoint between two successive computed full moons, so this method for predicting solar eclipses by the Babylonians is indeed very crude compared to their later method which has an average error of about three hours. Hence we must dismiss this first Babylonian attempt at predicting solar eclipses (special conjunctions) as inferior and not to be included in the chronology with their later methods.

The conclusions are that the Babylonians were able to predict lunar eclipses by about 750 BCE with a time error of about one hour, and the Babylonians

were able to predict possible solar eclipses about 360 BCE with a time error of about three hours. The Babylonians started the practice of predicting the sighting of the new crescent about 450 BCE.

[11] Transmission of Babylonian Astrology-Astronomy to other Peoples

For some decades of the 20th century Erica Reiner was the primary editor of the multi-volume Akkadian dictionary project during its development at the University of Chicago. One of her students in the study of Akkadian is Francesca Rochberg, who is one of the world's leading scholars of this ancient language. On page 11 of Rochberg's book in 2004 about the ancient Akkadian authors and their writings that span the period from ancient Assyria to the first century, she wrote, "In the ancient Near East, our sources do indeed indicate an indisputable progressiveness in astronomy.

Nonetheless, the realms of 'astronomy' and 'astrology' were not separate in Mesopotamian intellectual culture, and so a self-conscious distinction between them such as we make in using these terms does not emerge in the cuneiform corpus." On page 10 we find, "In the horoscopes in particular, an interdependent relationship between astrology and predictive astronomy is demonstrable by the identification of connections among a variety of astronomical text genres and the content of horoscopes. Celestial divination, which carries through from the middle of the second practically to the end of the first millennium B.C., and the Babylonian astronomy of the post-500 B.C. period provide the intellectual context for the Babylonian horoscopes, which bear relation to both of these distinct traditions. Because of these relationships, the horoscopes afford a unique view into Late Babylonian astronomical science." On page 41 we find, "... from a social point of view, Late Babylonian astronomy was supported by the institution of the temple." Also on page 41 we find, "It is clear that the individuals who computed astronomical phenomena were the same as those who copied omen texts and constructed horoscopes." On page 165 we find, "The following discussion is limited to those ideas that can be extracted from and supported by the literature of the Babylonian scholar-scribe who specialized in divination and took part in its related activities, such as prayer, incantation, or, indeed, the mathematical prediction of lunar eclipses."

At the time of the captivity and exile of the House of Judah to Babylon from 604 to 586 BCE, the common language of Babylon was Aramaic, but the written language of the Babylonian priests, who produced mathematical astronomy with its base 60 positional numbering system, continued to be the

Akkadian language of the previous Assyrian Empire. Because of their positional numbering system and their motivation to use predictive astronomy for astrological purposes that gave them prestige and income, these Babylonian priests developed generalized methods for multiplication and long division of fractional numbers. Thus the scientific language of the Babylonian priests who were the mathematical astronomers was hidden from the general population that had ceased using the Akkadian language. Except for the private use by these priests, the Akkadian language ceased being a living language.

The prophet Daniel was given great authority in the secular government during the period c. 600 to c. 540 BCE, and based upon the biblical account in Daniel 2, he and his three friends were highest in the government. The Babylonian pagan temple priests were simultaneously reduced in authority. On page 209 Francesca Rochberg wrote, “One determinable change in the environment of later Babylonian scholarship was the shift of the locus of astronomical activity from the palace [i.e., support by secular government] to the temple [pagan support]. When exactly this occurred, however, is not well documented.” On this same page we find, “By the fourth century B.C., however, evidence for the intense involvement of the king with the [pagan priestly] scholars appears to diminish.” Rochberg neglected to see the excellent documentation in the Bible! When Daniel gained authority under King Nebuchadnezzar, he reduced the influence of the pagan priests who practiced their mixture of astrology with astronomy. Eventually they were ousted from the palace and took refuge in the pagan temple where they continued their practices. Both Ezra and Nehemiah, c. 450, were given favor by King Artaxerxes, and undoubtedly the pagan priests remained in disfavor with the king. On page 235 Rochberg wrote, “Regardless of the way astronomy functioned within the temple institution, association with the temple was without doubt the key to the survival of Babylonian astronomy for so many centuries after it had become seemingly defunct in the political sphere.”

There is no historical evidence to indicate any cooperative sharing between the Levitical priesthood and the pagan Babylonian astrologers-astronomers who continued writing their documents in the Akkadian language, which the general population did not understand. The Akkadian cuneiform script was vastly different from the 22-letter alphabet of both Hebrew and Aramaic. Akkadian script consisted of hundreds of wedge-shaped signs (see page 1 of Dalley). Since Scripture is opposed to the use of horoscopes (Isa 47:13), and

these were intimately associated with activities of the pagan temples where astronomy was pursued and preserved, zealous Levitical priests should have been motivated to stay away from such places and activities.

Pages 237-244 of Rochberg discuss the transmission of Babylonian astrology with astronomy to the Greeks after Alexander the Great conquered the Persian Empire in 331 BCE, and afterward to India. Astrology and astronomy were sent together as a package.

[12] Egyptian Astronomical Science before Alexander the Great

On pages 128-129 of Clagett, he wrote the following:

“It should be clear from my summary account that the ancient Egyptian documents do not employ any kinematic models, whether treated geometrically or arithmetically. However they did use tabulated lists of star risings and transits (as is revealed clearly in Documents III.11, III.12, and III.14), all tied to their efforts to measure time by means of the apparent motions of celestial bodies.”

“On more than one occasion in this chapter, I have remarked on the absence in early Egyptian astronomy of the use of degrees, minutes, and seconds to quantify angles or arcs, though slopes were copiously used in the construction of buildings, water clocks and shadow clocks, such slopes were measured by linear ratios.”

Otto Neugebauer (1899-1990) is unquestionably considered to be the greatest historian of ancient mathematical astronomy in the 20th century. He studied the ancient Egyptian language as well as the ancient Assyrian language known as Akkadian, and his pioneering studies were based on his own readings of the original texts. Before he began his studies on ancient Egyptian and Babylonian astronomy, he made a detailed study of their mathematics. His doctoral dissertation was on ancient Egyptian mathematics. It took his repeated efforts to convince Richard Anthony Parker, the most acclaimed expert on ancient Egyptian science and calendation, to join him as a professor at Brown University. Neugebauer and Parker published three volumes of ancient Egyptian astronomical texts from before the time of Alexander the Great (see Neugebauer and Parker). These many texts from ancient Egypt show that we have an understanding of their ancient knowledge of astronomy. These texts show no indication of the

abilities later achieved by the Babylonians and Greeks in predictive astronomy, as Clagett pointed out.

On page 559 of HAMA, Neugebauer wrote, “Egypt has no place in a work on the history of mathematical astronomy. Nevertheless I devote a separate ‘Book’ on this subject [10 pages] in order to draw the reader’s attention to its insignificance which cannot be too strongly emphasized in comparison with the Babylonian and the Greek contribution to the development of scientific astronomy.”

Concerning the extremely high accuracy of aligning the largest ancient Egyptian pyramids with the east-west direction, and hence a precise knowledge of the time of the equinoxes by the ancient Egyptians, Neugebauer wrote (1980) on pages 1-2, “It is therefore perhaps permissible to suggest as a possible method a procedure which combines greatest simplicity with high accuracy, without astronomical theory whatsoever beyond the primitive experience of symmetry of shadows in the course of one day.” A diagram and further discussion by Neugebauer explain how the Egyptians could have achieved the accurate alignments without any mathematically sophisticated theory.

Ronald Wells wrote a chapter titled “Astronomy in Egypt”, which concerns the time before Alexander the Great and his command to build the most modern city of ancient civilization, Alexandria. On page 40 of the book edited by Wells, he provides the following summary: “Historians of science concede only two items of [astronomical] scientific significance bequeathed to us by the ancient Egyptians: the civil calendar of 365 days used by astronomers even as late as Copernicus in the Middle Ages, and the division of the day and night into 12 hours each. These fundamental contributions may seem meager to many; engineering of the pyramids and surviving temples notwithstanding.”

Otto Neugebauer wrote (1945) on page 11, “It will be clear from this discussion that the level reached by Babylonian mathematics was decisive for the development of such methods [for the numerical study of astronomy]. The determination of characteristic constants (e.g., period, amplitude, and phase in periodic motions) not only requires highly developed methods of computation but inevitably leads to the problem of solving systems of equations corresponding to the outside conditions imposed upon the problem by the observational data. In other words, without

a good stock of mathematical tools, devices of the type which we find everywhere in the Babylonian lunar and planetary theory could not be designed. Egyptian mathematics would have rendered hopeless any attempt to solve problems of the type needed constantly in Babylonian astronomy.” On page 8 he wrote, “It is a serious mistake to try to invest Egyptian mathematical or astronomical documents with the false glory of scientific achievements or to assume a still unknown science, secret or lost, not found in the extant texts.”

Neugebauer wrote (1969) on page 78, “The handling of fractions always remained a special art in Egyptian arithmetic. Though experience teaches one very soon to operate quite rapidly within this framework, one will readily agree that the methods exclude any extensive astronomical computations comparable to the enormous numerical work which one finds incorporated in Greek and late Babylonian astronomy. No wonder that Egyptian astronomy played no role whatsoever in the development of this field.”

From the many ancient texts of the Egyptians we conclude that they did not apply mathematics to astronomy before the time of Alexander the Great. After that time, the city of Alexandria was founded and the leading Greek mathematicians and astronomers settled in that city of Egypt, so that it became the world's leading center of Greek astronomy. But this was not part of ancient Egyptian culture; instead, it was the transplanting of Greek science into Egypt by foreigners due to the newly constructed city of Alexandria with its modern marble streets and its grand marble museum and library. This combination museum and library with its many lecture halls became the best ancient equivalent to a modern university, and its library became the greatest one in ancient times.

[13] Did Abraham teach Mathematical Astronomy to the Egyptians?

The Jewish historian Josephus (37 – c. 100) wrote a history of the Jews that has many details that are not found in Scripture, and the question arises concerning whether these details are true. One of these details concerns the abilities of Abraham and the Babylonian knowledge of mathematical astronomy at the time of Abraham.

On page 83 of Josephus_4 we find at Antiquities 1:166-168, “For, seeing that the Egyptians were addicted to a variety of different customs and

disparaged one another's practices and were consequently at enmity with one another, Abraham conferred with each party and, exposing the arguments which they adduced in favour of their particular views, demonstrated that they were idle and contained nothing true. Thus gaining their admiration at these meetings as a man of extreme sagacity, gifted not only with high intelligence but with power to convince his hearers on any subject which he undertook to teach, he introduced them to arithmetic and transmitted to them the laws of astronomy. For before the coming of Abraham the Egyptians were ignorant of these sciences, which thus traveled from the Chaldaeans into Egypt, whence they passed to the Greeks."

The previous conclusions that were attained from archaeology with the help of computers and the modern knowledge of mathematical astronomy are now restated. The Babylonians were able to predict lunar eclipses by about 750 BCE with a time error of about one hour, and the Babylonians were able to predict possible solar eclipses about 360 BCE with a time error of about three hours. The Babylonians started the practice of predicting the sighting of the new crescent about 450 BCE. But Abraham lived c. 2000 BCE, before the great achievements of Babylonian mathematical astronomy occurred. Furthermore, ancient Egypt did not possess mathematical astronomy until the Greeks emigrated there and brought it with them after the death of Alexander the Great in 323 BCE. We therefore conclude that Josephus did not know the history of the acquisition of mathematical astronomy by the Egyptians, and it does not make sense to believe that Abraham knew any significant mathematical astronomy himself.

About a century before Josephus, other Jews bragged about Abraham's achievements, even in astrology! The interested reader may consult pages 146-151 of Gruen.

[14] Did Ancient Israel Excel in Advanced Mathematical Astronomy?

A good deal of effort has been put into the history of ancient astronomy in previous chapters in order to evaluate what could have been known by ancient Israel at the time of Moses and afterward. Ancient Israel used single letters of their Hebrew alphabet that represented large numbers in a manner similar to the Roman numeral system. They did not use a positional number system with a zero as we do today. This is a great handicap that prevents performing generalized multiplication and long division, which is essential for mathematical astronomy.

The ancient Israelites from the time of Moses in Egypt could not have borrowed mathematical astronomy from Egypt because Egypt did not possess mathematical astronomical knowledge until it was brought there by Greek astronomers more than 1000 years after Moses died. From biblical chronology I estimate that the Israelite exodus from Egypt occurred c.1480 BCE.

Jewish scholars do not claim that the ancient Israelites had abilities in mathematical astronomy that surpassed that of their ancient neighbors. There is no historical evidence for it. On pages 555-556 of Langermann we find, "Although the sun, moon, and stars are mentioned in the Hebrew Bible, that ancient and sacred text does not display any sustained exposition which can be called an astronomical text. The earliest sources for a Hebrew tradition are found in a few passages in the Talmud and Midrash [c. 200-600 CE]."

The Babylonian Talmud, specifically the section designated Rosh Hashanah 25a (RH 25a), which is on page 110 of BT-RH, quotes Rabban Gamaliel II of Yavneh as having said, "I have it on the authority of the house of my father's father [Gamaliel the Elder from the early first century] that the renewal of the moon takes place after not less than twenty-nine days and a half [day] and two-thirds of an hour and seventy-three halakin." Since there are 1080 halakin in one hour, this is 29.5 days 44 minutes 3 1/3 seconds. Thus RH 25a claims that from one new moon to the next new moon is at least this length of time. On page 308 of Swerdlow this is shown to exactly equal the value used by the Greek astronomer Hipparchus (c. 190 - c. 120 BCE) for the average length of the month, which he wrote in the base 60 as $29;31,50,8,20$ days, which equals $29 + 31/60 + 50/(60 \times 60) + 8/(60 \times 60 \times 60) + 20/(60 \times 60 \times 60 \times 60)$ days. But did Hipparchus derive this value himself? No! The paper by Toomer 1980 discusses this value for the average lunar synodic month in more detail. On page 108 footnotes 6 and 11 he clearly points out (as he implied on pages 98-99) that the Babylonians had already derived this value at an earlier time, and thus he shows that this value was not first computed by Hipparchus, but accepted as true by Hipparchus and taken by him from the Babylonians. Toomer also gives credit to Asger Aaboe for a paper he wrote in 1955 indicating that Aaboe realized that this number came from the Babylonians rather than Hipparchus. On page 98 Toomer credits F. X. Kugler as apparently recognizing this in a book he wrote dated 1900. On pages 168, 240-241 of Hunger and Pingree it is stated that this length of an average synodic month comes exactly and

directly from column G in the Babylonian lunar System B, and on page 236 this book states that the earliest tablet containing System B material from Babylon is dated 258 BCE. Hence this number was derived by the Babylonians some time before 258 BCE. On page 54 of Britton 2002, John Britton estimates the origin of the mean synodic month to c. 300 BCE.

How might ancient people determine the length of a lunar month? By taking two widely separated eclipses of the same kind and when the moon is traveling at about the same point in its cycle of varying velocity, and then dividing the time length between them by the number of lunar months, one may estimate the average length of a synodic month. Hipparchus was trying to compute eclipse periods, and for this purpose he used two old records of eclipse observations from Babylon that he possessed as well as two eclipse observations from his own lifetime. From these two pairs of eclipses Toomer's paper explains that a computation of the average lunar synodic month would in fact disagree with the number that he received from Babylon, but Hipparchus accepted their number anyway. The last of the base 60 numbers above is 20, but the computation from Hipparchus' eclipse records would instead round off this last number to a 9. While the long division computation gives a different number, the difference between these values is less than a tenth of a second! How accurate are these numbers (20 and 9 for the last place) compared to the true value of the average lunar synodic month near the time of Hipparchus and the earlier Babylonians?

On page 87 of Depuydt 2002, Leo Depuydt provides the following estimated modern computations for the mean synodic month in the years 2000 BCE, 1000 BCE, and 1 CE, and I have converted these to the Babylonian base 60 system. The computed estimated time is based upon eclipse records going back to 747 BCE and the assumption that the trend continued in a similar way prior to that date.

2000 BCE 29d 12h 44m 2.08s = 29; 31, 50, 5, 12
1000 BCE 29d 12h 44m 2.29s = 29; 31, 50, 5, 43.5
1 CE 29d 12h 44m 2.49s = 29; 31, 50, 6, 13.5

Compare the above modern computed lengths of the mean synodic month through time with that of the Babylonians and the Greek astronomer Hipparchus below.

Babylonians c. 300 BCE = 29; 31, 50, 8, 20 (also the Talmud)

Hipparchus' data c. 150 BCE = 29; 31, 50, 8, 9

We have seen that the Babylonian Talmud, which was released by Jewish scholars c. 600 CE, uses the exact time length of a mean synodic month that originates from ancient Babylonian astronomers at roughly 300 BCE, yet the Talmud refers back to the house of Gamaliel in the first century for this figure. Is it reasonable to think that some Israelites derived this time for the average length of a lunar month independently on their own? No it is not, because this number is slightly under one second too large based upon the above data. The use of different eclipse records for a computation ought to give a different result. The paper by Toomer points out that the Greek astronomer Ptolemy of Alexandria c. 150 CE wrote about the achievements of Hipparchus 300 years earlier, and both of them realized that picking a different pair of eclipses from which to compute the average length of a lunar month would provide a different result. Ptolemy discussed the specific nature of which eclipse records would likely produce a more reliable result, and he based this on the earlier work of Hipparchus. The reason for the use of different eclipses producing a different result is that the apparent speed of the moon as observed from the earth varies at different times of the month, at different times of the year, and at different times of the eclipse cycle known as the Saros, which is 223 mean synodic months (18.03 years). Thus any computation based upon a specific pair of eclipse observations will result in a unique value for the average length of a lunar month, although properly chosen records will provide close results.

The Babylonians began predicting the visibility of the new crescent at roughly the year 400 BCE, and this prediction is based upon an accurate understanding of the moon's cycle for repeating its speed variation, or lunar anomaly, within the Babylonian System A (see the paper by Britton 1999, especially page 244). The cycle of lunar anomaly is the Saros cycle. From roughly this time onward they would be in a good position to be able to judge which pair of eclipse records should produce an accurate figure for the average lunar synodic month. As stated above, the oldest existing Babylonian System B material is dated 258 BCE, and this system includes the fundamental parameter that Hipparchus used for the mean synodic month, which was championed by Ptolemy c. 150, and was later incorporated into the Babylonian Talmud c. 600. We have no explicit knowledge of exactly when or exactly how this length of the mean synodic month was determined within System B by the Babylonians, although it is a very reasonable conjecture that some pair of eclipse records from the same

part of a Saros cycle was a key. On page 45 of Britton 2002, John Britton estimates the origin of System B to be as early as c. 330 BCE, but on page 54 his estimate for the origin of the mean synodic month is c. 300.

Pages 13 and 22 of Spier show that the modern calculated Jewish calendar uses the approximation for the average length of a month from RH 25a in the Babylonian Talmud, yet we now know that this came from ancient Babylonian astronomers c. 300 BCE. The Babylonian Talmud is called “Babylonian” because its Jewish authors lived in Babylon at the time of its production c. 600 CE, not about 900 years earlier when the Babylonian astronomers derived this figure. But other factors are also used for the modern calculated Jewish calendar, which are not due to either ancient Babylon or Hipparchus, and are not found in the Talmud. Num 10:10 shows a responsibility of the Levitical priesthood in declaring the “beginning of the months”, and thus control of the calendar and its knowledge could be expected to have been passed down from generation to generation via the hereditary priesthood. However, after the Temple was destroyed in 70 CE the Levitical priesthood vanished from Jewish history along with its influence over the calendar. No writings from this priesthood have survived from before the destruction of the Temple, except for the fact that Josephus was a priest who was born in 37 CE and died c. 100. While his writings exist, none of them were written before the destruction of the Temple, and he does not discuss when a month begins in any direct way. He never mentions any astronomical calculations being done by the ancient Jews, and neither does Philo of Alexandria (c. 20 BCE - c. 50 CE).

In order to perform the mathematical computations for general long division of fractional numbers that would be necessary for predictive astronomy, it would be necessary to utilize a number system with a base, which would therefore enable a positional notation and the use of a symbol for zero. For computational uses without a computer, modern society uses the base 10 for ordinary purposes, although modern computers use the base 2, and for the sake of human ease of readability, the base 2 is typically converted to base 16 (hexadecimal) for computer professionals. The Babylonians and Greeks used the base 60 number system for their capable calculations. After the achievements of the Babylonians and Greeks in the Eastern Hemisphere, the Mayan Indians in the Western Hemisphere used the base 20 number system. The way that the Hebrew text of the Bible expresses numerical values indicates that the ancient Israelites did not use a positional number system with a base and a symbol for zero.

Hence, from a mathematical viewpoint along with the lack of any archaeological evidence to the contrary (although there are archaeological discoveries in the site of ancient Israel), it is safe to conclude that ancient Israel, before the destruction of Solomon's Temple by Nebuchadnezzar in 586 BCE and the three waves of Israelite exile to Babylon from 604–586 BCE, did not possess the type of mathematical abilities that would have enabled them to perform the mathematical computations needed for success at predictive astronomy.

The ancient pagan Babylonian priests were interested in astrology. They predicted the future of kings and kingdoms. They gained wealth and political prestige through this practice until Daniel told both the dream and its interpretation to the king (Daniel 2). They then lost political prestige, but their pagan practices continued as they developed horoscopy. Some of these pagan priests were the predictive astronomers. Their desire for wealth and prestige led to their efforts at computational and predictive astronomy. The Greeks had a greater interest in science for the sake of knowledge, although they too were interested in astrology and its use to gain wealth. The leisure time to devote to astronomy came from the wealth gained by astrology.

The historical evidence indicates that neither the ancient Israelites before the destruction of Solomon's Temple in 586 BCE nor the Jews after this until the destruction of the Second Temple in 70 CE sought to develop their own mathematical astronomy. Ancient Egypt before Alexander the Great did not possess any predictive mathematical astronomical knowledge, so ancient Israel could not have inherited such knowledge from them. Neither the Bible, nor archaeology, nor Jewish history give any indication that Israelites before the destruction of the Second Temple in 70 CE had advanced abilities in mathematical astronomical knowledge. It was not until the time of Alexander the Great, that ancient astronomers were able to approximately predict the time of the true conjunction.

The difference in time between the computed average time of the conjunction (based on repeated additions of the average synodic lunar month, which is employed in the modern calculated Jewish calendar) and the true conjunction is about 14 hours according to page 45 of Wissenberg. Thus the modern calculated Jewish calendar (MCJC) is not based upon predicting the true conjunction. The Jews at the time of Moses were not using the

MCJC with its adoption of the Babylonian length of the average month, and they were not able to calculate the time of the conjunction.

[15] Appointed-times and Years are known from Lights in the Sky

I will examine Gen 1:14-15 to show that appointed-times and years are determined from lights in the sky.

Gen 1:14, “And the Almighty said: Let there be lights [3974 *mahohr*] in the expanse of the heavens to separate between the daytime and between the night, and let them be for signs, and for appointed-times [4150 *moed*], and for days and years.”

Gen 1:15, “And let them be for lights [3974 *mahohr*] in the expanse of the heavens to give light on the earth, and it was so.”

In verse 15 the word “them” refers back to the subject in verse 14, namely the lights. Thus verse 15 is saying in essence, “let the lights be for lights ... to give light on the earth”. Even the names of the heavenly bodies are absent to put emphasis on the “light bringing” purpose and mission of these heavenly bodies to fulfill the need to determine “signs, appointed-times, days, and years”. The triply emphasized mission of light from the heavenly bodies to supply light to determine appointed-times and years must be given its appropriate place in thought and use.

The word “signs” [226 *oht*] in Gen 1:14 is used for the rainbow in Gen 9:12-13, for the ten plagues in Egypt, for the Sabbath in Ex 31:13, 17, for a miracle in Judg 6:17, for the prediction of two deaths in I Sam 2:34, and in other ways. Gen 1:14 is saying that the lights in the heavens are examples of signs. Carefully reread Gen 1:14 to note that it is not saying that signs [226 *oht*] are to determine the appointed-times and years. The subject of the sentence is the lights in the sky, not the signs. The lights in the sky determine signs. The lights in the sky determine appointed-times. The lights in the sky determine days. The lights in the sky determine years. Verse 15 shows that it is some aspect of the light from these lights in the sky that cause the determination.

For the sake of completeness and to continue to show the use of the light from these heavenly lights, I now literally translate Gen 1:16-18.

Gen 1:16, “And the Almighty made the two great lights [3974 *mahohr*], the greater light [3974 *mahohr*] to rule the daytime and the lesser light [3974 *mahohr*] to rule the night, and [He made] the stars [to rule the night].”

Gen 1:17, “And the Almighty set them in the expanse of the heavens to give light upon the earth”

Gen 1:18 “and to rule by daytime and by night, and to separate between the light and between the darkness.”

The nature of the rulership of the heavenly lights mentioned in verses 16-18 is the dominance of their light, which again puts emphasis on the light from these lights. At the end of verse 16, concerning the stars, I added in brackets “to rule the night” because that is exactly what is mentioned about the heavenly lights, including the stars, in verse 18.

There are people who teach that the biblical month begins at the sundown of a day when the moon cannot be seen at all. Some people will use the time of the conjunction (astronomical new moon). I will call this theory the invisible moon theory or the conjunction theory. This is contrary to the biblical emphasis and stress on the use of **light** to determine the appointed times.

On various occasions I have heard advocates of the conjunction theory claim that before the Babylonian captivity under Nebuchadnezzar, ancient Israel (specifically the House of Judah) determined the start of a month with the sundown that began a day, but the moon was invisible near that sundown. These people go on to claim that after the return from captivity under Ezra and Nehemiah, Israel, under the influence of the Babylonian calendar and Persian political dominance, no longer continued the alleged original practice since the time of Moses. To judge the rationality of this view, let us read a couple of verses from Neh 8.

Neh 8:2, “And Ezra the priest brought the law before the assembly of men and women and all who could hear with understanding on the first day of the seventh month.”

Neh 8:9, “And Nehemiah who [was] the governor, and Ezra the priest the scribe, and the Levites who taught the people, said to all the people: Today is holy to YHWH your Almighty.”

Since the day that is stated to be the first day of the seventh month is definitely declared to be holy, it must have been determined correctly, and this was after the return from the captivity under Ezra and Nehemiah. Hence

they could not have adopted a pagan practice contrary to what was correct under the law as taught by Moses. The Levitical priesthood had the proper pattern to determine the start of a month set in motion from this day onward down through the later centuries until the Temple was destroyed in 70 CE, and there is no known time during which the priesthood is thought to have had any significant doctrinal upheaval in its own ranks during this period.

[16] A Month is a Cycle of the Moon

No discussion has yet been given concerning the meaning of appointed-times in Gen 1:14.

Ps 104:19, "He made the moon [3394 *yahrayach*] for appointed-times [4150 *moed*], the sun knows its going-away."

This use of appointed-times establishes that the moon is one of the heavenly bodies specifically indicated in Gen 1:14.

I Ki 6:38, "And in the eleventh year in the month [3391 *yerach*] Bul, it [is] the eighth month [2320 *chodesh*], the house was finished for all its parts and for all its plans, thus he built it seven years."

I Ki 8:2, "And all the men of Israel were assembled toward King Solomon at the feast in the month [3391 *yerach*] Ethanim, which [is] the seventh month [2320 *chodesh*]."

Strong's number 3394 for moon (*yahrayach*) and Strong's number 3391 for month (*yerach*) have the same three Hebrew consonants and look the same when the vowels points are removed. (In the Hebrew language the 22 letters shown in the sections of Ps 119 are called consonants even though some of them act as vowels. The original Hebrew text of the Scriptures only had these 22 consonants. The vowels points (and some such marks are more than points, but that is the term by which they are called in Hebrew school) were added to aid pronunciation by the Masoretes about the year 650. This identical original appearance in the Hebrew word for moon (3394) and the Hebrew word for month (3391) shows that a biblical month is a cycle of the moon. These verses, I Ki 6:38; 8:2, also have another word for month [2320 *chodesh*], and it shows that the two different words, *yerach* and *chodesh*, indicate the same thing, a month.

[17] Full Moon occurs about the 14th and 15th Days of the Biblical Month

Ancient Semitic writings in Ugaritic that are discovered through archaeological excavations do not show the vowel signs that have been common to biblical Hebrew since c. 650 when the Masoretes added these marks to help the reader to pronounce the words. Scholars who transliterate the Ugaritic words into English letters do not add the vowels because they are not in the original writings. Scholars often write the Hebrew letter *chet* as *h* instead of *ch* as I have done. If the vowels are omitted and only one English letter is written for one Hebrew letter, the two Hebrew words for month could be written *yrh* and *hds*, instead of *yerach* and *chodesh*. In words that are cognate between Ugaritic and Hebrew, the sound for *t* in Ugaritic often replaces the sound for the letter *shin* (written *sh* or merely *s*) in Hebrew. The Ugaritic language has the cognate words for both of the Hebrew words for month, and scholars write them *yrh* and *hdt*!!!

The Hebrew word for “day” is *yom*, and without the vowel marks, it is *ym*, The Ugaritic cognate word for “day” is also written *ym*!!!

On page 270 of the book by Pardee where he discusses the pagan context in the Ugaritic Kingdom, we find the following about the Ugaritic word *yrh*, “*yrh*, cognate with Hebrew *yareh*; ‘new moon’ is expressed by the word *hdt* alone, literally ‘newness,’ in the phrase *ym hdt*, ‘day of the new moon’; the plural *hdtm* in text 58 (RS 19.015.13) designates a series of ‘royal sacrificial feasts’ extending over an unknown number of months; ‘full moon’ is expressed by *mlat*, literally ‘fullness,’ also with the word for ‘day’ (*ym mlat*, ‘day of the full moon’); in terms of sacrifices offered, the new moon festival was less important than that of the full moon.”

On pages 271-272 of the book by Gregorio del Olmo Lete, we find the following, “According to its heading, the Ugaritic text KTU 1.109 can be defined as ‘a sacrificial new-moon ritual,’ either on a particular month or, more probably, during each month of the year. In any case, this is the only indication of *time* for the ritual act: the 14th-15th day of the month, *ym mlat* (lit.: ‘day of fullness’). The translation of the Ugaritic text is given as follows on page 273, “On the fourteenth day the king washes (remaining) purified. On the day of the full moon two month-old head of cattle are felled as a banquet offering to Balu of Sapanu, (plus) two ewes and one ‘domestic’ dove; ...”

As was discussed near the beginning of this study, the Hebrew language of ancient Israel developed using the basic vocabulary of the language of Canaan and the nearby peoples, so that the cognate words of the same context should have the same meaning. From the Hebrew words in the Scriptures relating to the cognate words in Ugaritic, this shows that the full moon occurs near the 14th or 15th day of the biblical month.

[18] A Biblical Month is a Whole Number of Days

A cycle of the moon around the earth is about 44 minutes more than 29.5 days, but in this chapter we shall see from some verses using both of the Hebrew words for month, namely *chodesh* and *yerach*, that biblically speaking, a month is a whole number of days, with no fraction remaining. In Judea in the first century the Jewish culture did use a common term for hour, but earlier in ancient Israel's history, there is no small subdivision of time such as hours or minutes. However, by some unknown means, the night was apparently split into three "watches" (Ex 13:34; Judg 7:19; Ps 63:6; 90:4; 119:148; Lam 2:19).

If there is always clear weather for good visibility, and the sighting of the new crescent is made from Israel, then every month should have 29 or 30, days. This is not true for all places on the earth. For example, with good visibility from southern Australia, on rare occasions there can be a 31-day month.

The literal expression ***a month of days*** as seen in several verses below, is idiomatically translated ***a full month*** in almost all translations. These examples show that a biblical month is a whole number of days.

Gen 29:14, "And he dwelt with him a month [2320 *chodesh*] of days."

Num 11:19, "You shall not eat one day, or two days, or five days, or 10 days, or 20 days,"

Num 11:20, "[but] until a month [2320 *chodesh*] of days, until it comes out from your nostrils, and it will be loathsome to you because you have rejected YHWH who is among you, and you have wept before Him saying, Why did we go out of Egypt?"

Num 11:21, "And Moses said, the people [are] 600,000 on foot among whom I am, and You said, I will give them flesh that they may eat a month [2320 *chodesh*] of days."

Deut 21:13, “and she shall put off her captive's clothing and remain in your house, and grieve for her father and mother a month [3391 *yerach*] of days. And after that you may go in to her and be her husband and she will be your wife.”

II Ki 15:13, “Shallum the son of Jabesh reigned in the 39th year of Uzziah, king of Judah, and he reigned a month [3391 *yerach*] of days in Samaria.”

[19] A Biblical Month has a Maximum of 30 Days

We have seen that a biblical month is a cycle of the moon around the earth, and it is a whole number of days. A cycle of the moon averages a little more than 29.5 days. Suppose the moon cannot be seen at all for some number of days when the month would normally be expected to end? How many days can a biblical month continue if the moon is not seen at all? There is a prophetic time when the moon will not give its light.

Isa 13:9-10, “Behold the day of YHWH comes, cruel with both wrath and fierce anger, to lay the land desolate. And He will destroy its sinners from it. For the stars of heaven and their constellations will not give their light. The sun will be darkened in its going forth, and the moon will not cause its light to shine.”

Note the similarity to Joel 2:1-2; Ezek 32:7-8. The time length of the lack of light from the moon is not clear from this. All of the “day of YHWH” may be included, and the use of the word “day” here may refer to a lengthy time.

To students of biblical prophecy the context of Dan 7:21-27 fits that of the day of YHWH. The following begins to explain an important prophetic time period called a “time and times and half a time”.

Dan 7:25, “He shall speak pompous words against the Most High, shall persecute the saints of the Most High, and shall intend to change times and law. Then *the saints* shall be given into his hand for a time and times and half a time.”

This identical expression is also mentioned in Dan 12:7 and Rev 12:14. The context of Rev 12:14 fits perfectly with Rev 12:6, and the latter is explicitly stated to be 1260 days.

The beast of Rev 13:6 fits perfectly with the beast of Dan 7:25, which is the fourth beast in Dan 7:7-8, 19-27. The “time and times and half a time” in Dan 7:25 was already shown to refer to 1260 days. Therefore, the 42 months that are mentioned in Rev 13:4-6 is the same time period of 1260 days, which is a “time and times and half a time”.

Now “ $42 \times 30 = 1260$ ” and here “42 months is 1260 days. In this circumstance a month divides out to be 30 days. This may be explained by recognizing that the moon will not give its light, as shown above in Isa 13:9-10 and Ezek 32:7-8.

The result of this examination is the conclusion that a month is not permitted to have more than 30 days if the moon does not give its light or is not visible.

While some people may conjecture that astronomy will be altered to miraculously force a month to have 30 days at this future time, it seems more rational that the miracle of the lack of light from the moon will prevent a month from exceeding 30 days.

There is another miracle associated with “the shadow of the sun dial of Ahaz going back 10 degrees” in II Ki 20:11 and Isa 38:8. But the context associates this with the time of Sennacherib, king of Assyria, in II Ki 19:35-37; 20:6; Isa 38:6. The 14th year of Sennacherib is mentioned in both II Ki 18:13 and Isa 36:1, and secular history along with biblical reference works date this to 701 BCE. However, archaeological evidence from Babylonian cuneiform inscriptions of astronomical eclipses and other events perfectly agree with computer calculations going backwards to 747 BCE, which verify the unchanging continuation of the orbits of the heavenly bodies back to that time. This proves that the miraculous event associated with “the shadow of the sun dial of Ahaz going back 10 degrees” was a miracle as perceived by people concerning the miraculous placement of light and shadow. Although a literal translation of Isa 38:8 appears to say that the sun itself moved back 10 degrees, the context is discussing the shadow of the sun moving 10 degrees rather than the sun itself. Hence “the shadow of” should be added in italics in order to read, “So *the shadow of* the sun returned 10 degrees” in verse 8.

People have conjectured that astronomy became altered during “Joshua’s long day” (see Josh 10:12-13). The earth rotates on its axis to produce the

visual effect of the sun moving around the earth. But the sun does not actually move around the earth. When Joshua requested that the sun stand still, this was according to Joshua's perception that the sun actually moved rather than the earth rotating. In this miracle, according to the literal Hebrew wording, both the sun and the moon appeared to stop moving according to human perception, so that light would be provided for the battle. The Bible is not clear how this miracle came to pass. This may have been a miracle of light perception or light movement rather than a temporary cessation of the rotation of the earth and a temporary cessation of the movement of the moon around the earth, or some other alteration of orbits involving the sun, earth, and moon. An astronomical alteration would have required a combination of many miracles including the prevention of massive ocean floods upon many shores as well as the falling of buildings and the imbalance in standing living creatures during the massive change in bodily momentum as the earth's rotation would have been affected. It is far more plausible that the miracle involved human perception of light rather than an alteration in the relative position of the heavenly bodies. In any case, Joshua's request does not take into account the reality of what happens astronomically, namely, that the earth rotates instead of the sun moving around the earth. There is too little information about this in the Bible to conclude that orbits were altered.

During the time of the flood there is another unusual association with the length of a month. Gen 7:11 mentions that the flood began on the 17th day of the second month. In Gen 8:3-4 the wording seems to imply that 150 days passed until the 17th day of the seventh month. Here five months seem to total 150 days, which divides out to 30 days per month. This may be explained by realizing that with so much water covering the earth, there would be thick clouds (with much rain at the beginning), so that when the month would normally begin, no moon could be seen to mark its beginning. Therefore, the maximum length of the month, namely 30 days, would be permitted.

The extent of a month is from one sundown to some later sundown, with a total of 29 or 30 days, at least in theory. In practice, if there is a succession of months for which the sky is cloudy or rainy over all of Israel where people reside on days near the start of each of those months, then each of those months will have the maximum number of days per month, namely 30 days. Then, when the weather first becomes clear at the start of a month, that month may have less than 29 days to make up for the artificial prolongation of some months to 30 days.

[20] The Sun and Moon are the Primary Lights in Gen 1:14

To explain the significance of the translation “appointed-times” in Gen 1:14, let us now consider the following.

Lev 23:2, “The appointed-times [4150 *moed*] of YHWH which you shall proclaim [to be] holy convocations, My appointed-times [4150 *moed*] are these:”

Lev 23:3, “Six days work may be done, but on the seventh day is a Sabbath of rest, a holy convocation, you shall not do any work, it is a Sabbath to YHWH in all your dwellings.”

Lev 23:4, “These [are the] appointed-times [4150 *moed*] of YHWH, holy convocations which you shall proclaim in their appointed-times [4150 *moed*]:”.

These verses show that the appointed-times discussed in this chapter are days upon which there is to be a holy convocation. In Lev 23:3 note that the appointed-times include the Sabbath that repeats every seventh day. But this Sabbath example of an appointed-time [4150 *moed*] is not determined by the moon; instead it is determined by counting days, and days are determined by the alternation of darkness during the night followed by light during the day. This alternation of darkness and light is a result of the alternation of the absence and presence of the light from the sun, so that the sun is involved in determining this appointed-time, the Sabbath, but the moon is not involved for the following reason. Each month (or specific cycle of the moon) there are from one to three nights during which the moon cannot be seen at all, even with clear weather. During this period of invisibility of the moon, the days that are counted to arrive at the Sabbath have no contribution in counting light by the moon because the moon cannot be seen at that time. Notice the following description of rulership or dominance by the light of the heavenly bodies.

Ps 136:7, “To Him who made the great lights ...”

Ps 136:8, “The sun to rule in [the] daytime ...”

Ps 136:9, “The moon and the stars to rule in [the] night ...”

These verses show that the sun and moon are called the great lights, but the stars are also said to rule in the night. If it is not cloudy or rainy all night (and sometimes it is), it is possible to count the days by counting the nights

during which one sees the stars as well as the daytimes during which one sees light given by the sun. However it is not possible to count days by counting the light from the moon due to its varying period of invisibility each month.

The use of the sun rather than the moon to determine the count to the Sabbath as an appointed-time, as well as calling the sun and the moon “the great lights” in Ps 136:7-9 and declaring the moon to be for appointed-times in Ps 104:19, show that the sun and moon are the major contributors as lights to determine the appointed-times.

When one considers all the lights in the sky (sun, moon, stars, planets, and comets), the stars, planets, and comets do not have a cyclical period that matches the cycle of the year on the earth. Due to precession of the equinoxes, every 1000 years the stars shift 14.1 days further away from the vernal equinox. Therefore, by eliminating the other choices from consideration, the last word in Gen 1:14, “years” must involve the sun in some way.

[21] Blowing two Silver Trumpets on the Day that Begins each Month

Num 10:1-2, “And YHWH spoke to Moses saying, Make yourself two trumpets of silver. You shall make them of a hammered piece. And they shall be for summoning the assembly and for the breaking of the camps [to prepare to travel].”

The Hebrew noun (used as a gerund) that I translated “summoning” is *meekra* and has Strong's number 4744 (see BDB page 896, column 2). The Hebrew noun that I translated “assembly” is *adah* and has Strong's number 5712 (see BDB page 417, column 1).

Num 10:8, “And Aaron's sons, the priests, shall blow with [the two silver] trumpets.”

Num 10:10, “And on [the] day of your gladness, and on your appointed-times [4150 *moed*], and on the beginnings of your months [2320 *chodesh*], you shall blow with [the two silver] trumpets over your burnt offerings and over [the] sacrifices of your peace offerings, and they shall be to you for a memorial before your Almighty; I am YHWH your Almighty.”

Two general purposes are mentioned for these two silver trumpets in verse

2: (1) summoning the assembly, and (2) for the breaking of the camps. The latter purpose is relevant during the 40 years of wandering in the wilderness when they journeyed from place to place, and they also journeyed when going to war. Whenever the relevant people were called together for the purposes mentioned in this section, the trumpets were blown in specific ways to signal the nature of the event.

This shows that the Levitical priests were to blow two silver trumpets on all the important occasions, which included the first day of each month as well as on the appointed-times, and the latter include each seventh day recurring Sabbath as shown in Lev 23:2-3.

[22] Hebrew *chodesh* refers to the Day that Begins each Month

Now compare Num 10:10 with I Chr 23:30-31.

I Chr 23:30, “and [the sons of Aaron are] to stand every morning to thank and to praise YHWH, and likewise at evening,” I Chr 23:31, “and for all the burnt offerings to YHWH for the Sabbaths, for the new-moons [2320 *chodesh*], and for the appointed-times [4150 *moed*] in the count [of animals], [according to the] ordinance concerning them continually before YHWH.”

In I Chr 23:31 above we notice that the burnt offerings on the new moons [2320 *chodesh*] are mentioned, and in Num 10:10 above we notice that the burnt offerings on the beginnings of your months [2320 *chodesh*] are mentioned. The whole phrase “beginnings of your months” appears in verse 10 compared to “new-moons” in verse 31, showing that a month begins with a new moon. Verse 31 translated this word *chodesh* as “new-moons”, while verse 10 translated the same word as “months”. Other examples also show a double meaning for this word. Some examples where *chodesh* means “month” are Gen 29:14; Num 10:11; I Ki 5:14. Some examples where *chodesh* means “new-moon” are II Ki 4:23; Ezek 46:3; Hos 2:11; Amos 8:5. The last verse indicates that in ancient Israel the new moon day was treated as a public holiday where businesses were closed, although refraining from work on a new moon is not stated as a commandment in the law of Moses.

It has already been shown that a cycle of the heavenly body called the moon determines a month. The translation “new-moon”, but without the hyphen, is the common translation for *chodesh* when it refers to the beginning of a month. Nevertheless, one may question whether “new-moon” is the best way

to translate *chodesh*. Based upon Num 10:10 one may translate this single Hebrew word as “month-start” or “new-month” since it is definitely the beginning of a month. As already seen above, the word for moon is *yahrayach* [3394], which has no resemblance to *chodesh*. No Hebrew word for the physical body called the moon has a resemblance to the Hebrew word *chodesh*.

It is only through the other Hebrew word for month, *yerach* [3391], that we have the connection to the physical body known as the moon. On this basis it would be more literal to translate the Hebrew word *chodesh* as “month-start” or “new-month”. The Hebrew noun *chodesh* [2320] has the same consonants as the Hebrew adjective *chadash* [2319] (almost always translated “new”) and the Hebrew verb *chadash* [2318] (about half the time translated “renew” and half the time “repair”). The month following any month is not a renewal of the previous month or a repair of the previous month; instead it is indeed a new month. While the translation of *chodesh* as “new-month” seems more literal and precise than “new-moon”, the latter is so firmly accepted that this will be used in the present study.

What about the suggestion to translate *chodesh* as “renewed-moon”? The moon itself is older than it was the previous month and the physical body itself is not renewed. If one wishes to make a case for translating the word *chodesh* as “renewed-moon” based upon the light from the moon, this is quite subjective because *chodesh* has the primary affinity with month, and the month is “new”, not “renewed”.

If we apply Num 10:1-2, 8, 10 to the beginnings of the months as specified in verse 10 along with “summoning the assembly” in verse 2, the following conclusion is drawn. Two priests were to blow two silver trumpets to summon the assembly and thereby announce that a new month had begun.

Deut 16:16 shows that only three times during the year all men are commanded to appear at one central place, not at the start of all the months. Therefore, the summoning of the assembly at the beginning of their months pertained to those people that were near the one place where the two silver trumpets were blown and the sacrifices were performed, not all people throughout the nation.

Num 10:10 shows the authority of the priesthood in declaring the start of each month through the blowing of the two silver trumpets. Num 28:11 also has the same phrase “and on the beginnings of your months”. The passage in Num 28:11-15 describes the burnt offerings, the grain offering, and the drink offering that is specific for the priests to perform on the beginnings of their months. At this time when the people heard the specific sound of the two silver trumpets blown by the two priests, they then knew that the ceremony of the offerings for the beginning of the month were to begin soon. This sound would summon the people who were within a reasonable distance to come and witness the priestly ceremonies associated with the beginning of the month. This would be an occasion for prayers, singing, and playing musical instruments when the priesthood fully developed the service for the beginning of the month.

[23] The Biblical New Moon relates to the Sighting of the New Crescent

We have seen that a month is a cycle of the moon, and the full moon typically occurs on the 14th or 15th day of the biblical month. We have also seen from Gen 1:14-18 that a month begins using the light from the moon as a visual indicator. The only visual discernable candidates for the biblical new moon that are available from this information are the old crescent and the new crescent.

Ancient Egypt had a civil calendar that ignored the cycle of the moon. But according to page 140 of Depuydt 1997, ancient Egypt also had a religious calendar that began its month with the morning one day after the old crescent was seen in the morning. The reason they waited until the morning after the morning on which the old crescent was seen, is that they could not know that the old crescent was actually the old crescent until one morning later when nothing was seen. When a narrowing crescent is not especially thin, maybe it will not be the old crescent or maybe it will. This can only be known one morning later because the old crescent is, by its definition, the last of the narrowing crescents during the moon’s cycle. This requirement to wait until one morning after the old crescent is one significant difference between the determination of the old crescent and the determination of the new crescent. When the new crescent is seen, it is immediately known because it had not been seen the night before.

In the previous chapter it was mentioned that Hebrew noun *chodesh* [2320] (meaning *month* as well as *new-month* or *new-moon*) has the same

consonants as the Hebrew adjective *chadash* [2319] (almost always translated “new”, and having the meaning “new”) and the Hebrew verb *chadash* [2318] (about half the time translated “renew” and half the time “repair”). Hence the collective association of **new**, **renew**, and **repair** is associated with the Hebrew word **chodesh**, rather than the concept of old, dwindling, or thinning, which is associated with the old crescent. Therefore, from the choice of the Hebrew word *chodesh* for the new-moon, it must refer to the new crescent rather than the old crescent.

An astronomical reason for a biblical month consisting of a whole number of days is that each new crescent first becomes visible close to sundown when the Sabbath begins and when a numbered day of the month begins. We thus see that from the biblical viewpoint, the average synodic month as a precise fraction of days, hours, and minutes is never hinted at in Scripture and is foreign to biblical thought.

Ezra 6:15 mentions the month Adar and Neh 6:15 mentions the month Elul. These are Hebrew transliterations of month names in the Babylonian calendar, but these verses are in the context of Jerusalem. Scripture is a witness here that ancient Israel adopted the month names of the Babylonian calendar at the time of Ezra and Nehemiah. This would cause severe confusion unless a biblical month began by the method of the Babylonian calendar. Indeed, a month in the Babylonian calendar began with the day whose beginning evening was close to the time that the new crescent was seen in the western sky. But no month was permitted to have more than 30 days in the Babylonian calendar. This corroborates what was already determined from other biblical and archaeological evidence.

[24] Philo of Alexandria and the Jewish New Moon in the First Century

As a Jew living in Alexandria, Egypt in the early first century, Philo discusses the new moon from his Jewish perspective. On page 333 of Philo_7 (Special Laws 2:41) Philo wrote, “The third [feast recorded in the law] is the new moon which follows the conjunction of the moon with the sun.” Since this follows the conjunction, it must refer to the (visible) new crescent. On pages 391 and 393 of Philo_7 (Special Laws 2:141-142) Philo wrote, “Following the order stated above, we record the third type of feast which we proceed to explain. This is the New Moon, or the beginning of the lunar month, namely the period between one conjunction and the next, the length of which has been accurately calculated in the astronomical schools.

The new moon holds its place among the feasts for many reasons. First, because it is the beginning of the month, and the beginning, both in number and in time, deserves honour. Secondly, because when it [the new moon] arrives, nothing in heaven is left without light, for while at the conjunction, when the moon is lost to sight under the sun, the side which faces earth is darkened, when the new month begins it resumes its natural brightness. The third reason is, that the stronger or more powerful element [the sun] at that time [the new moon] supplies the help [light] which is needed to the smaller and weaker [the moon]. For it is just then [at the new moon] that the sun begins to illumine the moon with the light which we perceive and the moon reveals its own beauty to the eye.”

In Alexandria, the leading center of Greek mathematical astronomy at that time, the conjunction is a well known concept to Philo, and he mentions the conjunction as a contrasting time to the new moon. It is clear that to Philo the Jew in the early first century in Alexandria, the new moon is the new crescent, and this begins the first day of the Jewish month. Evidently the Greek geometrical abstract concept of the conjunction had filtered down to the educated non-astronomer, Philo. He used this concept in writing to his audience without defining it, so he understood that his audience would also understand this term.

[25] Did the Jews use Calculation for their Calendar in the First Century?

On page 302 of *The Mishnah* the section Rosh Hashannah 2:8 appears, which Neusner subdivided into parts “A” through “I” as follows, and Neusner wrote what is in square brackets below. This is quoted word for word.

A. A picture of the shapes of the moon did Rabban Gamaliel have on a tablet and on the wall of his upper room, which he would show ordinary folk, saying, “Did you see it like this or like that?”

B. M'SH S: Two witnesses came and said, “We saw it at dawn [on the morning of the twenty-ninth] in the east and at eve in the west.”

C. Said R. Yohanan Nuri, “They are false witnesses.”

D. Now when they came to Yabneh, Rabban Gamaliel accepted their testimony [assuming they erred at dawn].

E. And furthermore two came along and said, “We saw it at its proper time, but on the night of the added day it did not appear [to the court].”

F. Then Rabban Gamaliel accepted their testimony.

G. Said R. Dosa b. Harkinas, “They are false witnesses.”

H. “How can they testify that a woman has given birth, when, on the very next day, her stomach is still up there between her teeth [for there was no new moon!.]”

I. Said to him R. Joshua, “I can see your position.”

Now I have some comments on the above.

(A) Due to the other names, this is considered to be the grandson of the Gamaliel in the NT, and this is considered by Orthodox Jews to be in the second century, perhaps about 110.

(B) The story may be invented to illustrate the stature and greatness of Gamaliel II. One cannot accept the historical truthfulness of everything in the Mishnah.

(C) Part A above is taken by Orthodox Jewish commentators including Maimonides to imply that Gamaliel II was able to calculate what the new moon should look like and whether it could be seen, and through his questioning of the witnesses and his calculations he could judge whether the witnesses were lying. But this is reading far too much into what is said. Assuming that this is historically true, Gamaliel may simply be trying to rattle the witnesses, so that they would not try to falsely testify. In other words, he wanted to see how confident they would be in their claim. Each year at about the same season, the angle of the new crescent would be generally the same, but not exactly the same. Thus an ignorant person would not know approximately what it ought to look like, but a knowledgeable person would know its approximate angle, although a knowledgeable person at that time in history would not know in advance whether it would be seen. On the other hand, in the majority of cases months did alternate with 29 and 30 days.

(D) This is the entire evidence that exists of the claim that in ancient times learned Jews could calculate whether the new crescent could be seen.

(E) The claim in B is false because it is not possible to see the old crescent and the new crescent so close together in time.

(F) The statement at the end of E indicates that on the next night the court was not able to see the new crescent, and this is the reason for the analogy given in part H.

(G) Parts G and I indicate that some people doubted that the alleged witnesses saw the new crescent, despite the fact that Gamaliel II accepted their testimony.

(H) The whole procedure and interest in obtaining witnesses for having seen the new moon should make it obvious that if its visibility was declared at the end of the 29th day, then the ending month had only 29 days. Hence they were not using a calculation to determine the start of a month.

From the above, does it seem rational to accept the opinion and interpretation that in the early second century Jewish leaders could calculate whether the new crescent could be seen? Certainly not.

[26] The Biblical Year is a Whole number of Biblical Months

A **tropical year** is the average time from one vernal equinox to the next vernal equinox, or equivalently, from one autumnal equinox to the next autumnal equinox. In ordinary speech this is also called the solar year, and it approximates the agricultural year without drifting away.

Since a biblical month averages about 29.5 days, a 12-month period will contain about 354 days and a 13-month period will contain about 384 days. But a tropical year contains about 365.2422 days, which is about 11 days more than 12 biblical months.

Leviticus 23 is the most concentrated single area of the Hebrew Bible dealing with calendaric aspects of the festival days. Upon reading through Lev 23 it should be noted that months are never mentioned by name in this chapter, but always by numbered occurrence through the year. Thus once the first month is determined, all the other months are determined because they

follow sequentially by number. The first month maintains a fixed relationship to the festivals. But now it will be shown that the festivals maintain a fixed relationship to the agricultural year in Palestine. Ex 34:22 shows that the Feast of Weeks approximates the wheat harvest. Ex 23:16 shows that the Feast of Ingathering approximates a harvest time of the year. Deut 16:13 shows that the Feast of Booths approximates a harvest time of the year, but a comparison of Ex 23:14-17 and Deut 16:16 shows that the Feast of Ingathering is the same as the Feast of Booths. Since there is no harvest in Palestine during late autumn and winter, the festivals must maintain an approximately fixed relationship to the agricultural year. Therefore, the first month must maintain an approximately fixed relationship to the agricultural year and hence the tropical year. Technically this is expressed by saying that the biblical calendar is lunar-solar in nature.

The Bible has an example of a year with 13 months, showing that the biblical year was not an exact tropical year. Here is the example. The time difference between Ezek 1:1-2 and Ezek 8:1 is the difference between month 4 day 5 in the 5th year of King Jehoiachin's exile and month 6 day 5 in the 6th year of his exile. This is 14 or 15 months depending on whether the 5th year of his exile had 12 or 13 months. If the difference is 14 months, this is about 29.5 times 14 (= 413) days with an overestimate of 30 times 14 (= 420) days. The overestimate of 420 days is 17 days short of the known events because Ezek 3:15 accounts for 7 days and Ezek 4:4-6 accounts for 390 plus 40 days, the total being 437 days. Thus the difference must have been 15 months, which is about 29.5 times 15 (= 442.5) days, just five or six days more than the known events of that time period.

If one should claim that the 5th year of the king's exile was a tropical year, and an overestimate of 366 days ("leap" year) plus 60 days (two extra months) is allowed, the total is 426 days, which is still far short of the 437 days for the known events.

Thus, although the biblical year maintains an approximately fixed relationship to the agricultural year, the example with 13 months shows that the biblical year is not an exact tropical year.

It will now be shown that a biblical year consists of a whole number of biblical months rather than a smaller subdivision such as days. A biblical reason for this is that Num 28:14 has the Hebrew expression *chodesh bh chadshoh lh chadshay ha shanah*, meaning "month by month for months of

the year”, but idiomatically “each month throughout the year”. Also, I Chr 27:1 has the Hebrew expression *chodesh bh chodesh lh col chadshay ha shanah*, meaning “month by month for all months of the year”, but idiomatically “each month throughout the whole year”. The above example of a year with 13 months is further biblical evidence that a year consists of a whole number of months.

A biblical year cannot contain fewer than 12 months because Est 9:20-23, 26 maintains that each year on the 14th and 15th days of the month Adar the Jews are to celebrate the festival called Purim. Est 8:12 states that Adar is the 12th month. If a year could only have 11 months, then the Jews would be unable to celebrate Purim that year. Further evidence of a requirement of at least 12 months in the year comes from I Ki 4:7 and I Chr 27:1-15.

Hence a biblical year contains 12 months or 13 months, or approximately 354 days or 384 days. This is an illustration of the fact that the modern cultural concept of a year always having 365 or 366 days need not necessarily be practiced in some ancient societies.

In ancient Egypt, from some time onward, their civil calendar always had 365 days, which was divided up into 12 months of 30 days each plus five extra days (see page 28 of the reference by Ronald Wells). The time of the establishment of the 365-day Egyptian civil calendar has not been convincingly proved. However, from writings that have survived from Elephantine, Egypt during Persian rulership over Egypt, the double dating scheme that equates certain dates in the Egyptian calendar with dates in the Babylonian calendar unquestionably demonstrates that from 471 BCE onward into the Middle Ages this Egyptian calendar was used (see Horn and Wood 1954, Parker 1955, and Porten 1996). Since this calendar loses about 1/4 of a day each tropical year, in 120 years it would lose about 30 days. The Egyptians certainly realized that this calendar would continuously lose time in comparison to the agricultural year, but it did not stop them from using it anyway. Furthermore, this Egyptian calendar became the preferred calendar by which the best Greek astronomers in Alexandria recorded their astronomical observations, although they knew it fell short of the tropical year, which they measured quite accurately.

The main point in all this is to emphasize that any practical ancient calendar may have a concept of a *year* associated with that calendar, so that such a calendar *year* need not equal the tropical year. As long as a society considers

a calendar *year* sufficiently practical for its use, it may use such a *year* for centuries regardless of its lack of accuracy compared to the tropical year. For ease of computation in whole numbers and payment for months worked, it is convenient to use 12 months of 30 days each and thus use a civil calendar of 360 days. The existence of such a calendar *year* does not provide evidence that a tropical year ever actually contained 360 days. The only way that such a claim could be proved is if there was historical evidence that the agricultural year actually averaged 360 days over many years, or if surviving archaeological statements associated with astronomical cycles claimed or directly implied that a tropical year equaled 360 days. This question of whether there is any known evidence in man's history for a 360 day tropical year has come up twice on the web site for discussions on the history of astronomy, HASTRO-L, since I became a member in 2000, and thereby received all its emails since then. HASTRO-L is the only on-line discussion group exclusively devoted to the history of astronomy on the Internet. HASTRO-L has many active contributors who are professors of history and professors of astronomy. There is no historical evidence that a tropical year ever equaled 360 days, although there is evidence for an ancient calendar having 360 days in certain areas of the ancient Middle East.

Some people have conjectured that during the time of the biblical flood in the days of Noah, a tropical year or a biblical year had 360 days. This remains unproved speculation. Chapters 7 and 8 of Genesis do not claim that each of the periods of time mentioned are non-overlapping, and do not claim that the sum of these time periods fully cover one exact year. The belief that a tropical year at the time of Noah had exactly 360 days is mere speculation.

[27] The Beginning of the Month and I Samuel 20

I Samuel 20 is very instructive to show how the biblical month began during the time of Samuel the prophet when King Saul reigned. It will be shown from the wording of this chapter that no calculated calendar could have been used at this time in Israel's history.

At this time of David's young adulthood, he has already experienced attempts by King Saul to kill him (I Sam 18:10-11; 19:9-10), but his very close friend Jonathan, the king's son, has great difficulty believing that his father wants to kill David. In order to convince Jonathan that Saul wants to kill David, David devises a plan to cause Saul to reveal his attitude toward

David in the presence of Jonathan. Notice that this plan involves a day count of three from the following literal parts of verses.

I Sam 20:5, “until the third evening”.

I Sam 20:12, “about [this] time the third morrow”.

I Sam 20:19, “and [on the] third [day]”.

This shows their advance confidence that it would probably take two successive days for Saul’s actions to bring to light his attitude toward David. They expected that Jonathan would witness two consecutive days of Saul’s behavior. The context assumes that the reader will automatically understand this without any explanation. We need to carefully examine the context to note what the writer of the text expected the reader to know.

I Sam 20:5, “And David said to Jonathan, Behold, tomorrow [is a] new-moon, and I should sit with the king to eat ...”.

I Sam 20:18, “And Jonathan said to him, Tomorrow [is a] new-moon, and you will be missed because your seat will be empty”.

These two verses show that it was considered important for David to be present at a banquet hosted by the king due to a “new moon”, and there was a seat reserved for David. There is nothing in the context to suggest that this was the beginning of the seventh month and that a holy convocation was to take place. Indeed, if this had been the beginning of the seventh month, verses 5 and 18 would have more to say about why David would be missed! The reason given is the new moon, nothing more.

The Hebrew syntax in verses 27 and 34 is the same for one phrase that is not like any place in the Hebrew Scriptures where a numbered day of the month is mentioned. The Hebrew word order is “the *chodesh* the second”, which occurs that way four times in the Hebrew Bible: I Sam 20:27, 34; I Ki 6:1; I Chr 27:4. In the latter two places it means “the second month”. This expression “the *chodesh* the second” does not have the Hebrew word *yom* for “day”, does not have a preposition attached to the beginning of the number, and has the number after the word *chodesh*. These three factors do not occur in any place where a numbered day of the month is mentioned in the Hebrew Bible. A Hebrew expression for a numbered day of the month occurs 98 times in the Bible. In 92 of these cases the Hebrew preposition *bh* (meaning “in” or “on”) precedes the number. In two of these cases the

Hebrew preposition *ad* (meaning “until”) precedes the number. In 39 of these cases the Hebrew word *yom* (meaning “day”) occurs at the number. While there are a total of four cases (Ezra 3:6; 10:17; Est 9:19, 21) in the Hebrew Bible where a numbered day of the month is mentioned and no preposition is prefixed to the number, all of these cases do have the Hebrew word *yom*, and none of these four cases have the number after the word *chodesh*. There is no example in Scripture with the syntax as in I Sam 20:27, 34 to indicate that it could mean a numbered day of the month.

The Hebrew word *chodesh* sometimes means “new-moon” and sometimes means “month”, but because the syntax of this phrase in these two verses is never used for a day of the month, and because its meaning as “new moon” here gives a satisfying explanation to the context including the planned meeting of Jonathan and David on the third day from their initial meeting, *chodesh* will be translated “new-moon” below.

I Sam 20:27 literally states, “And it happened on the morrow of the new-moon the second, [the] place of David was empty. Then Saul said to Jonathan his son, Why didn't the son of Jesse come either yesterday or today to the meal?”

When the NASB is used, items in square brackets will show where the NASB has italics, indicating that no Hebrew word occurs for the italics. It may sometimes be useful to consider omitting the words in square brackets in the NASB because they are not based on words in the Hebrew text.

I Sam 20:27 [NASB], “And it came about the next day, the second [day of] the new moon that David's place was empty ...”

Thus there was something special about that meal on two successive days that made David's presence expected at both meals.

In verses 28 through 33 Saul and Jonathan dialogue with one another so that Jonathan becomes convinced that Saul wants to kill David.

I Sam 20:34 literally states, “And Jonathan arose from the table in fierce anger, and did not eat food on [the] day of the new-moon the second because he was grieved for David, for his father had dishonored him.”

I Sam 20:34 [NASB], “Then Jonathan arose from the table in fierce anger, and did not eat food on the second day of the new moon, for he was grieved over David because his father had dishonored him.”

I Sam 20:35 literally states, “And it happened in [the] morning that Jonathan went out [into] the field at [the] time appointed [with] David, and a little boy [was] with him.”

The morning in verse 35 is within the third day that David and Jonathan had planned to meet.

The special meal at the king's table on two successive days during which the presence of David, a national hero, was expected, shows that both meals were to commemorate the start of the month. The need existed to have two days of commemorative meals because they did not know in advance which of the two days would in fact begin the new month. From I Sam 20:27 we can say that David and Jonathan did not know in advance which of two successive days would officially be declared the new moon day, because otherwise there would not have been a need for two successive days of a festive meal during which David was expected to appear. The phrase in I Sam 20:5, 18 that “tomorrow is a new-moon” is literally misleading because it can be expected to cause the reader to think that they knew in advance that tomorrow would in fact actually be the first day of the new month. It should be translated “tomorrow is the new moon [festivity]”.

I Sam 20:5, 18 was applied to the first day to come, and the designation of “new-moon the second” was given to the second day to come. The need to have a second day of commemoration indicates that on the first of the two days, the new moon was not officially declared by the Levitical priesthood to be the start of a new month by the blowing of two silver trumpets in accordance with Num 10:10.

The average length of a month is close to 29.5 days, and most of the time there is an alternation of 29 and 30-day months, although there certainly are exceptions. At the time that David and Jonathan first met, one would surmise that the previous month had 29 days, so that it was most likely that the current month that was nearly over would have 30 days. Thus, when David and Jonathan first met, they planned for the current month to be a 30-day month so that their next meeting would be on the third day rather than on the second day. They believed it was most likely that a second festive

meal day would be needed due to an expected 30-day month. Therefore, when I Sam 20:5 and 18 speak of “tomorrow [is the] new-moon”, that refers to the festive national holiday (not holy day) on the first of two successive days during which the new month might begin. The author of I Samuel 20 expected the reader to understand that there was to be at least one, and possibly two, successive days of festive meals at the king's table at the start of each month.

The start of a month is used to determine festivals, so by Gen 1:14, the light of a heavenly body must determine the start of a month. The first light of the moon would not anciently be known until it was seen. I Sam 20 is evidence that the day of the new moon was not pre-calculated, because otherwise there would not have been a need to plan for two successive days of festive meals. A pre-calculation would have been calculated to precisely one day rather than a choice of two days.

I Sam 20:5 and 18 should be understood to mean “tomorrow [is the] new-moon [festivity]” rather than the officially declared new moon. In other words, David and Jonathan did not really know that “tomorrow” would actually be the first day of the new month. In fact they expected that “tomorrow” would not be the first day of the new month!

When reading Josephus, one must be on guard for any reason that Josephus might have for distortion in his account of an event. In his description of I Sam 20 it is difficult to see any reason why he might deliberately distort any technicalities of the story. This chapter should not have been a controversy among Jews in the time of Josephus. He was certainly living at a time when Hebrew was still spoken among the upper class in Jerusalem where he was reared in the first century. Josephus was born in the year 37, so he was 32 or 33 years old when the Temple was destroyed in 70.

Josephus corroborates the translation of ***second new-moon*** in his paraphrase of I Sam 20:27. On pages 283 and 285 of Josephus_5, Ant 6:236, we read, “But when, on the second day of the feast of the new moon, David again did not appear, he asked his son Jonathan why, both on the past day and on this, the son of Jesse had been absent from the festive meal.”

The Greek word that Josephus uses for “new moon” in the above translation is *noumeenia* (Strong's number 3561), not the Greek word *meen* (Strong's number 3376), which means “month”. Thus the NASB, taking the Hebrew

syntax as it is, translates it so as to agree with Josephus who chose the Greek word for “new moon” rather than the Greek word for “month”. The William Whiston translation is very poor here because he translates it as though Josephus used the other Greek word (*meen*).

Page 861 of the chapter by Moshe David Herr translates I Sam 20:27 “But on the morrow of the second new moon ...”, and translates I Sam 20:34 “... and he ate no food the second new moon day”. According to pages 84-85 of the book by Cahn, the Karaite Benjamin Nahawendi c. 825 CE understood I Sam 20:27, 34 similarly. The German interlinear translation by Rita Steurer also translated these verses using the German translation equivalent to “second new moon” rather than “second day of the month”. The German word for new moon is different from the German word for month.

On page 36 of the book by Solomon Gandz he wrote, “There can be no doubt that ‘on the morrow of the second new moon’ [in verse 27] has the same meaning as ‘on day of the second new moon’ [in verse 34] and that both phrases refer to the second day of the new moon festival, on which a festive meal was given at the King’s table and in which David was supposed to take part.” The very title of the chapter by Gandz is “The Origin of the Two New Moon Days”, and his analysis is consistent with the analysis given here, although his arrangement of the explanation is different and he does not use all of the logic presented here.

Within the above quote from Gandz, I have added the items in square brackets, and the two expressions enclosed within apostrophes have, in Gandz' work, the Hebrew words rather than the literal translation that I have substituted. Gandz discusses this chapter and Jewish commentaries upon it during the past 1700 years.

Horace was a Roman poet and satirist who wrote in Latin and lived from 65 BCE to 8 BCE. On page 20 of the book by Horace, Satire 1.9.67-70 states: “‘Surely you wanted to tell me something, something confidential?’ ‘Oh, yes, but I’ll choose a better time. Today is the thirtieth Sabbath. Why offend the circumcised Jews?’ ‘I don’t care about religion’, I moan”.

Here the expression “thirtieth Sabbath” is a literal translation of Horace's Latin expression *tricesima Sabbata*. On page 375 of the book by Louis Feldman we find the following comment on this expression as found in the satire, “In summary, Horace's allusion in *tricesima Sabbata* is more effective

if it refers not to some meaningless nonsense but rather to the thirtieth, a Sabbath, that is, the New Moon, so prominently celebrated in Horace's time." Here it must be understood that the Jews desired to have a holiday (not holy day) on the new moon days. The Romans understood that the word Sabbath to a Jew meant a day on which he did not work at his ordinary job. It was easier for the Jews to tell the Romans that the new moon day that was the thirtieth of each month was always a Sabbath (called the thirtieth Sabbath) than to use other more accurate words from the biblical viewpoint. Biblically the new moon was not a Sabbath, but the Jews called it a Sabbath to simplify the implications of not working to the Romans.

The first of the two possible days of sighting the new crescent would place the first day of the month on the 30th day of the old month. Hence in Jewish practice of that time the 30th would be a holiday or a vacation day, and by loose extension (not technically correct), called a Sabbath. Since Horace expected his readers to understand him, this new moon holiday, called the "thirtieth Sabbath" was well known in Rome in the late second century BCE.

It was common knowledge in the Roman Empire during Horace's adulthood that Jews refrained from work on the first of the two possible days on which the new month might begin. This harmonizes perfectly with the implications from the Hebrew in I Sam 20:27, 34 and the whole chapter. The paraphrase by Josephus also agrees with this.

If Israelite society at the time of King Saul, when the prophet Samuel was still alive, was using a calculation to determine the start of the next month, there would have been no point in having two successive days of festive meals associated with the new moon, which shows an uncertainty of which day among two successive days that would start the month. Thus no calculated calendar could have been used at this time of Israel's history. Ancient Israel did not employ predictive astronomy for their calendar.

[28] Applying I Sam 20 to II Kings 4:23 and Amos 8:5

In II Ki 4:8-11 we see that a woman in Shunem made a room available for Elisha to lodge at whenever he was in that neighborhood. According to maps that are commonly available in some Bibles, and according to Josh 19:18, which shows Shunem within the boundary for the tribe of Issachar, Shunem was about 10 miles to the southwest of the Sea of Galilee (named differently

in Elisha's day). This is in the southern part of Galilee, about 60 miles north of Jerusalem, certainly not local to Jerusalem to be able to hear two silver trumpets blowing, and then soon going to witness a priestly ceremony for the beginning of the month. In II Ki 4:22 she asked her husband to prepare a donkey for her to ride upon to visit Elisha. In verse 23 her husband responded, "Why are you going to him today? It is neither the new-moon nor the Sabbath." This shows that under normal circumstances this wealthy woman rode a donkey to visit Elisha on the new moon and on the Sabbath. However, in I Sam 20, the day for a new moon festivity was simply called the new moon, and it occurred immediately after the 29th day of the month. The same is true in the days of the Roman poet Horace before the first century. Based upon this, we should understand the question in I Ki 4:23 to mean, "It is neither the new-moon [festivity] nor the Sabbath." This new moon festivity may be the first of two successive days of festivity.

Recognizing now, that the context with the Hebrew word *chodesh* for "new-moon" may mean "new moon [festival]", the reader should not be surprised if this translation is proposed for appropriate contexts. The prophet Amos criticizes many people in the land who complain as follows in Amos 8:5, "When will the new-moon [festival] be past that we may sell grain and the Sabbath [be over] that we may trade wheat?" This indicates that there were restrictions by the national government against some activities on the new moon festival, but it does not indicate that there was some law within the law of Moses that prevented certain work on such days; there is no such law. There is no sin where there is no law. Nevertheless, Amos 8:5 along with II Ki 4:23 does indicate that the population beyond Jerusalem did involve themselves to some degree with the new moon festivity.

Since the new moon festivity had significance throughout Israel, it would especially have significance where the High Priest, the ark, the Temple, and the ceremonial sacrifices took place. Although ceremonial details are not specified in Scripture, this implies that people near the Temple would witness the priestly ceremonies associated with the beginning of the month. However, there is no commandment in the law of Moses that ordinary work was forbidden or that attendance at this priestly ceremony was required for the beginning of the months.

[29] Rapid Communication to inform the Nation about the New Moon

Lev 23:24-25, “Speak to the children of Israel saying, ‘In the seventh month, on [the] first [day] of the month, you shall have a rest, a memorial of soundings, a holy convocation. You shall not do any servile work and you shall offer a fire offering to YHWH.’”

This first day of the seventh month was a festival day in which no ordinary work was done, and there was a commanded meeting with a festival service for this day. Deut 16:16 specifies the three times of the year when the adult male population was commanded to gather in one location within Israel, and the first day of the seventh month was not one of those three times.

Therefore, this festival at the beginning of the seventh month was kept at various local places throughout the nation. About half the months had 29 days and half the months had 30 days. These did not always alternate. The weather might be cloudy. Thus there would often be uncertainty whether the first of the two possible days for the new moon festivity would be the actual beginning of the seventh new month. With such uncertainty, the people would have no choice but to avoid normal work and have a holy convocation on the 30th day. If that first day would not be declared the actual beginning of the seventh month, they would then celebrate two consecutive days for the first day of the seventh month. A method of rapid communication would be needed to inform the local gatherings around the country that the first day of the new moon festivity was declared to be the actual start of the seventh month, if this had happened. Once the priesthood declared the first day to be holy, the next day was not holy. Rapid communication would make it unnecessary to celebrate a second day as a holy day in the local areas after the priesthood declared the first day to be holy.

How would rapid communication throughout all Israel be possible in ancient times?

When the new crescent is seen, shortly afterward the moon falls below the horizon and then there is no moonlight at all and it is very dark all night. This makes it dangerous to travel at night, whether to go to the top of some local hills or to return after arriving. A lantern could make travel possible, but it would be slow and still dangerous in total darkness. Consequently, regardless of the method of primitive communication (certainly no telephones, Morse code, or radio), it would have to wait until daylight. During some circumstances of difficulty in sighting the new crescent near Jerusalem, the priesthood might even have to wait until some time during the

middle of the following daytime to know whether to declare that first day as the true start of the new month.

Any big task is performed more quickly if multiple people are able to divide the task into smaller pieces, each one doing a small piece. For this to be effective in reducing the total time from start to finish, the time of their activity must overlap. Light travels much faster than people, horses, camels, or birds. Consider the following proposal. On the morning of the 30th day of the month certain people are appointed to travel to the top of designated hills throughout the country with materials that are able to start a controlled fire. The separated hills throughout the country would have to be close enough that they could see the fire from hills in the various directions. When the two silver trumpets were blown to announce the declaration of the start of the new month, the designated people who heard the trumpets would light their fires, and then this would rapidly spread throughout the country. The biggest time lag factor would be the time required to light the fire. It is even possible that a very small fire that could not be seen from far away was started first, and then this fire that was already kindled could speedily be used to start a larger fire that could be seen from other hills. Such a system could enable all of Israel to know about the declaration of the new month within a few hours during the afternoon of the 30th day. While it is perhaps possible to imagine this happening at night, it does not seem very likely because of the possible danger when visibility is impossible without a fire. Another problem with suggestions that the procedure occur at night is the likelihood that some of the watchers might fall asleep at night while waiting to see a fire at another hill. During the daytime it would be more interesting to be looking because there would at least be visible scenery.

There is documentation of such a fire system for rapid communication in the *Mishnah*, which was published c. 200 by Judah the Prince. This document cannot generally be trusted for historical accuracy concerning the early first century or 1000 years earlier for at least the following four reasons: (1) Possible doctrinal bias and genealogical bias by Judah the Prince or any written sources available to him; (2) Doubt that comprehensive written sources ever existed for religious practices that were supposedly copied from generation to generation by the priesthood; (3) Sometimes the statements of the laws are so detailed that one easily doubts that this was handed down in writing; and (4) Some of the practices seem to be politically motivated against the priesthood which vanished from history soon after the Temple was destroyed in 70. I reject the theory of the Oral Law, which asserts that

there was a body of law handed down without error in oral form (not to be written) from Moses onward until Judah the Prince was permitted to cast it into written form.

Despite these reasons for the lack of confidence in the infallibility of both doctrine and history within the Mishnah, such a fire system for rapid communication does make common sense and it is difficult to imagine why there ought to be doctrinal bias associated with the general concept even if some of the details are embellished and not trustworthy.

On page 301 of the *Mishnah* at RH 2:3 we find (square brackets are by Jacob Neusner),

“A. How did they kindle flares?

B. They bring long cedar wood sticks, reeds, oleaster wood and flax tow.

C. One binds them together with a rope.

D. And he goes up to the top of a hill and lights them.

E. Then he waves them to and fro and up and down, until he sees his fellow, doing the same on the next hilltop, and so on the third [and beyond].”

On the same page at RH 2:5 we find,

“A. There is a large courtyard in Jerusalem, called Bet Yazeq, to which all the witnesses gather.

B. And there the court examines them.

C. Now they prepare big meals for them, so that they should make it a habit of coming.”

On page 302 at RH 2:6 we find,

“A. How do they examine the witnesses?

B. The pair which makes its appearance first do they examine first.

C. They bring the elder of them and say to him, ‘Tell us, How did you see the moon? Was it facing the sun or turned away from it? Was it to the north or to the south? How high was it, and in which direction was it leaning? And how broad was it?’

D. If he said, ‘It was facing the sun,’ he has said nothing at all.

E. Then they would bring in the second party and examine him.

F. If their testimony coincided, their testimony was confirmed.

G. And in the case of all the other pairs of witnesses, they ask the main points,

H. not because they need their [evidence], but so that they should not go out disappointed,

I. so that they would make it a habit of coming along in the future.”

[30] Summary about the New Moon Celebration and the Role of the Daytime

In summary, the 30th day of each month was a national holiday, not a commanded holy day, except for the seventh month. Two successive days may be celebrated for the beginning of the seventh month, and indeed for the beginning of every month. The priesthood had certain commanded duties to perform at the beginning of each month, but this was only commanded in one location where two priests blew two silver trumpets to summon the assembly, thus announcing the beginning of the new month and alerting the local people that the time had arrived for them to come and celebrate the proceedings associated with the new moon ceremonies. Some of the population in various parts of Israel was involved in feasting on the 30th day of each month. Based on the example of I Sam 20, such feasting would also occur on the next day if the new moon was not declared on the 30th day.

The following are some practical factors that are associated with the 30th day:

- (1) There was a need to enable the whole of Israel to know whether the 30th day began the new month.
- (2) There was a need to wait for possible witnesses to arrive at the site where the two silver trumpets were waiting with the priests, and this might not happen until sometime during the following daytime.
- (3) Rapid communication would require the daytime to enable the whole nation to be informed of the day that began the month.

The daytime of the 30th day was an important part of the celebration, and not merely for a festive meal. While it is certainly possible that witnesses could arrive during the night, only during the daytime was it possible for significant numbers of local people to witness the ceremonies associated with the new moon, provided that the declaration was made. For that reason, even if witnesses arrived during the early part of the night, common sense would dictate that the priesthood would always want to begin the ceremonies at a time of the daytime when a maximum number of people could be present. Therefore, the daytime of the first day of each month was significant for the ceremonies and the people. The daytime was also significant for communication on the 30th day to the rest of Israel.

The sundown that began the 30th day was primarily significant in watching for the new crescent, not for the celebrations of that day if the new moon was declared.

[31] Today's Ambiguity in the Phrase *New Moon*

One source of possible confusion is the failure to realize that present day astronomers and almanacs define a new moon in a way that usually precedes the biblical new moon by one or two days. In order to avoid confusion, I will call the modern astronomer's new moon the **astronomical new moon**, not the *new moon*. Another modern equivalent expression for the astronomical new moon is the **conjunction of the moon with the sun**, or more briefly and simply, the **conjunction**. At the time of the conjunction no one can see the new moon.

[32] Biblical View of the Sun's Yearly Motion is South - North

Ecclesiastes mentions the sun (*shemesh* in Hebrew) more than any other book of the Bible - 35 times! One pair of verses gets specific about its motion, but this is only noticed if care is taken to preserve the Hebrew word order and if courage is exercised to allow the Hebrew to make sense! A literal translation of Eccl 1:5-6 with special attention to keeping the word order the same as it is in the Hebrew text is:

Eccl 1:5, "And rises the sun and goes [away] the sun and to its place it pants, rising it there [again].

Eccl 1:6A, It [the sun] goes toward south and turns around toward north.

Eccl 1:6B, Turns around [and] turns around goes the wind, and on its circuits returns the wind."

Page 55 of Zlotowitz translates Eccl 1:5-6, "And the sun rises and the sun sets - then to its place it rushes; there it rises again. It goes toward the south and veers toward the north; the wind goes round and round, and on its rounds the wind returns." On the next page appears the comment, "*Midrash Leckach Tov* [by Toviah ben Eliezer, 11th century] interprets this verse [verse 6A] as referring to the course of the sun as manifested by the winter and summer seasons, but it adds that on a deeper level the verses [5-6] refer to the Jews [they have moved from place to place due to persecution]."

About the year 400 CE Jerome translated the Tanak from Hebrew to Latin, which, except for the Psalms, became the Latin Vulgate. Page 307 of Japhet

gives the following careful translation from Jerome's Vulgate for Eccl 1:5-6, (additions in square brackets are made by Japhet), "The sun rises and [the sun] sets and returns to its place. It rises there, goes to the south and turns about to the north. As it circles the world around goes the spirit, and upon its circuit returns [the spirit]." Jerome made this rhyme in the Latin.

In general I never use the Septuagint translation (abbreviated LXX) as a means of understanding some seldom used Hebrew words or difficult passages of the Tanak because it often shows mere guesses for the Greek translation, so it is not reliable as an ancient indicator of the meaning of the Hebrew Bible. Among all of the books of the LXX, Ecclesiastes stands apart in a special way. Page 7 of Seow reveals, "The translation technique of LXX Ecclesiastes is unique among the books in the Bible, so that one may say with a reasonable amount of certainty that the translator is not the same as for any other books. The translation shows a number of features that are typical of the works of Aquila of Pontus, a second-century (C.E.) gentile convert to Judaism. Aquila, a pupil of the famous Rabbi Aqiba is best known for his translation of the Hebrew Bible into literalistic Greek [about 135 CE], among other reasons, to provide Jews who spoke Greek but did not read Hebrew or Aramaic with a translation that would reflect the Hebrew as much as possible. Thus, the Hebrew word order is rigidly adhered to and all details in Hebrew are represented, even when they seem awkward or even nonsensical in Greek." While scholars debate whether Aquila was the translator, we do know that the LXX for Ecclesiastes is literal and sticks very closely to the Hebrew. The commonly available translation of the LXX by Brenton translates Eccl 1:5-6, "And the sun arises, and the sun goes down and draws toward its place; arising there it proceeds southward, and goes round toward the north. The wind goes round and round, and the wind returns to its circuits." This translation reflects the fact that the word for "wind" does not occur in the Greek until after the word for "north". In fact, the Greek word order after "north" is "round round courses the wind", so Brenton's translation does put "wind" earlier in the verse than the Greek indicates. The Greek word *pneuma*, Strong's number 4151, is used for wind, which is the translation of the Hebrew word *ruach*, Strong's number 7307. Page 300 of Japhet translates the LXX more literally, "And the sun rises and the sun sets and draws to its place. It rises there, goes to the south and turns about to the north. Turns about, turning goes the *ruach* (*pneuma*), and upon its circuit returns the *ruach* (*pneuma*)." In footnote 31 on page 301 Japhet remarks, "This faithfulness to the MT [Massoretic Text of the Hebrew] is particularly striking when it creates forms which are awkward in the Greek."

Pages 298-299 of Japhet point out that Rashi, the well known Jewish commentator of the late middle ages, also treats the sun as the subject in Eccl 1:6.

The Syriac language is an offshoot of first century Aramaic and is thus a Semitic language that has affinities to Hebrew. The Syriac Peshitta is a translation from the Hebrew Bible that was made about 200 CE. The Peshitta in its literal word order, is in agreement with the Hebrew text of Eccl 1:5-6 in continuing with the sun as the subject of Eccl 1:6A; however, George M. Lamsa's translation from the Syriac Peshitta departs from the literal view and translates it as if the wind were the subject at the beginning of verse 6. Lamsa often departs from the Syriac to agree with the KJV.

Page xi of Sternberg translates Eccl 1:5-6A, "The sun rises and the sun sets and hastens to its place and rises there. It walks to the south and returns to the north."

In Sternberg's above translation the word "walks" comes from the Hebrew word *halach*, Strong's number 1980, which is typically used in reference to people walking, yet it is used in other ways for the movement of inanimate objects. However, from the viewpoint of an observer on earth, the position of the sun at sunset from day to day does change in distinct increments as a "walk", and the position of the shadow cast by a narrow object at noontime from day to day also changes in distinct increments as a "walk". These changes do form a south-north yearly cycle as will now be explained.

[33] The South - North Yearly Cycle indicated in Eccl 1:6A

A person who views sunsets daily from a place at which there is a clear view of the horizon might notice that the sun does not set at the same part of the horizon each day. He might think of performing the following experiment to determine the daily change in the position of the sun at sunset.

Permanently place a straight board and an object with a sighting point so that the middle of the board is about the length of a person west of the sighting point, and when looking approximately west with one's eye at the sighting point, the long top edge of the board is even with the horizon. Each day near sunset make a mark on the board where the board crosses the line of sight