Hebrew Calendar Science and Myths

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The following shows the arithmetic rules of the Hebrew calendar and demonstrates some of the more intriguing calculation results. In many instances, the arithmetic results appear to overthrow long-held assumptions related to the Hebrew calendar, thereby relegating these assumptions to the category of myths.

The arithmetic of the Hebrew calendar does not require any major mathematical skills. In fact, Maimonides once pointed out that

...the method of the fixed calendar is one which an average school child can master in 3 or 4 days. (*Hilkhot Qiddush HaHodesh 11:4*)

However, the development of the calendar's arithmetic rules embedded and demonstrated the considerable mathematical and scientific genius of the many unnamed scholars who devoted their skills to this unique problem.

Due to the nature of the arithmetic performed and the lack of corroborating reference for many of the results, I can only suggest that what is being demonstrated is reasonably correct to the best of my knowledge.

Conventions

For purposes of calculating the Hebrew calendar, the following conventions are to be noted.

The current Hebrew calendar rules are ASSUMED as fixed for all time periods both Past and future. All Hebrew years will be suffixed with a capital "H".

The current Gregorian calendar rules are ASSUMED as fixed for all time periods both past and future. All Gregorian years will be suffixed with the lower case "g".

Hence, 5757H is the year that spans both 1996g and 1997g.

For purposes of convenience, a Gregorian year 0g is assumed to have existed between -1g and 1g. 0g spans 3760H and 3761H. -1g spans 3759H and 3760H. 1g spans 3761H and 3762H. In this convention, 0g is a Gregorian leap year.

All Hebrew days begin at exactly 18:00 hours, which corresponds to hour 0 of the Hebrew calendar's day. So remember to recognize that in all subsequent calculations, hour 0 is actually 18:00 or 6 pm.

The rabbis also divided the hours into 1080 parts, thus making each part 3 and 1/3 seconds and each minute 18 parts. All calculations are done in days, hours and parts.

The week days are numbered as follows

0 = Saturday	1 = Sunday	2 = Monday	3 = Tuesday
4 = Wednesday	5 = Thursday	6 = Friday	7 = Saturday

The MOLAD Period

The time of birth of the new moon, is determined by the period of the MOLAD.

This period was determined to be **29 days, 12 hours, and 793 parts**.

The time of the *molad* is an arithmetical result of the calendar computations, which very accurately tracks the time of any mean lunar conjunction to within **1 day in every 15,304 *years***.

The 19 Year Cycle

The ancient Greek astronomer Meton (c. 4th cent. b.c.e.) observed that 235 lunation periods brought the solar year back into very close synchronization with the lunar years.

Thus, our scholars created a calendar cycle of 19 years consisting of 12 years of 12 lunar months each and 7 years of 13 lunar months each for a total of 235 lunar months.

GUCHADZaT - The Leap Year Distribution

Our scholars eventually declared years 3, 6, 8, 11, 14, 17, and 19 of the 19 year cycle to be leap years of 13 months each.

That distribution may be remembered by the mnemonic GUCHADZaT which stands for the Hebrew letters gimel-vov-het aleph-daled-zayyen-tet.

A given Hebrew year is a leap year whenever its value divided by 19 leaves a remainder that is 0, 3, 6, 8, 11, 14, or 17.

For example, the year 5757H (1996g/1997g) is a leap year because after division by 19, the remainder is 0. That by the way also makes it the last year of the 303rd 19 year cycle.

In a Hebrew leap year, a 30 day month is added to the year. This month is today known as the month of Adar I and is inserted immediately after the Hebrew month of Shevat. In our times, the insertion tends to take place in the February/March period of the Gregorian calendar year.

Presently, Hebrew leap years can begin no earlier than **September 5** and no later than **September 16**, while Hebrew common years can begin no earlier than **September 16** and no later than **October 5**.

The BaHaRaD

The BAHARAD is the acronym given to the time of the Molad shel Tohu. That took place on the 1st day of Tishrei in Hebrew year 1.

That molad took place on Sunday, September 6, -3760g corresponding to the time of Monday (bet) 5 hours (hey) and 204 parts (resh-daled).

In the way we denote these things, it is 2 days, 5 hours, and 204 parts.

The Hebrew days begin at 0 hours = 6 pm. Hence 5 hours on Monday is actually 11 pm on the civilian Sunday.

The Time of Any Molad of Tishrei

For any given Hebrew year HY, you first count the number of months that have elapsed since 1 Tishrei of Hebrew year 1.

To calculate the number of months, Wolfgang Alexander Shocken suggests on page 35 of his book "The Calculated Confusion of Calendars..." the following formula which I've slightly modified:

the integer of (235 * HY - 234) / 19

You then multiply the mean lunation time of 29 days; 12 hours; 793 parts by the integer result for the total number of months.

To that time is added the value of BaHaRad, and the result provides you with the time of the molad of Tishrei for any Hebrew year.

That value when reduced to days; hours (max of 23); parts (max of 1079) will give you the time of the molad for target year HY.

The total number of days is then divided by 7 and the remainder is the day of the week.

Hebrew Year Lengths

The above rules lead to Hebrew years which can have either 354, 355, 383, or 384 days.

The 4 Dehiyyot (Postponement Rules)

The date for Rosh Hashanah may be postponed by up to two days depending on the time calculated for the MOLAD.

The 4 special rules, each of which is called a dehiyyah (or postponement), and each of which serve a particular religious or arithmetic purpose are as follows.

Dehiyyah Lo ADU Rosh

If the Molad of Tishrei occurs on a Sunday, Wednesday or Friday then Rosh Hashanah is postponed to the next day.

The name ADU is an acronym formed from the Hebrew letters alef (=1 for Sunday) daled (=4 for Wednesday) vov (=6 for Friday).

Rule ADU prevents Yom Kippur from occurring on either side of Shabbat. It also prevents Hoshanah Rabbah from arriving on a Shabbat, as would happen if Rosh Hashanah were allowed to begin on Sunday.

Dehiyyah ADU increases the possible year lengths from 4 to 8. These lengths may include 353, 354, 355, 356, 382, 383, 384, or 385 days.

Dehiyyah Molad Zakein

The name for this rule is often translated as the "old moon" or "obsolete moon" rule.

If the Molad of Tishrei occurs at 18 hours (i.e. noon) or later of a permissible day, then the first day of Rosh Hashanah is postponed to the next allowable day.

This rule can postpone Rosh Hashanah by up to 2 days.

Some noteworthy scholars have suggested that this rule will guarantee the visibility of the new moon on the first day of Rosh Hashanah.

However, simple calendar arithmetic very strongly suggests that the molad zakein rule is no more than an arithmetical device which ensures that the calculated time of any molad does not exceed the first day of any Hebrew month.

Dehiyyah GaTaRad

If the Molad of Tishrei for a common year is on Tuesday; 9 hours; 204 parts or later, then Rosh Hashanah is postponed to Thursday.

Gatarad eliminates all 356 day Hebrew years. It is not found in the Talmud.

Dehiyyah BeTU'TeKaPoT

If the Molad of Tishrei following a leap year is on Monday; 15 hours; 589 parts or later, then Rosh Hashanah is postponed to Tuesday.

This rule eliminates all 382 day Hebrew years. It is not found in the Talmud.

Together, these 4 rules lead to 6 possible Hebrew year lengths, which can include 353, 354, 355, 383, 384, or 385 days.

Setting up the Calendar for year HY

The Hebrew months basically alternate between 30 and 29 days beginning with the month of Tishrei as follows:-

Tishrei 30	Heshvan 29	Kislev 30	Tevet 29
Shevat 30	Adar 29	Nisan 30	Iyar 29
Sivan 30	Tammuz 29	Av 30	Elul 29

For leap years, the 30 day month of Adar is added immediately after Shevat.

It is this particular placement of the leap month which forces the use of the Molad Zakein rule. Calendar arithmetic shows that if the leap month is placed prior to the month of Heshvan, then the Molad Zakein postponement rule is not required.

It is now necessary to compute the length of the year. Normally, this is done by finding the Rosh Hashanah date of the next year and differencing.

When the difference is 355 or 385 days, Heshvan gets a day to become 30 days. When the difference is 353 or 383 days, Kislev loses a day to become 29 days.

And there you have it... except that no one can tell you over which spot on Earth the Molad shel Tohu took place at BaHaRaD.

An Example

The time of the MOLAD for Tishrei 5758H is

2,102,728 days; 4 hours; 129 parts.

Dividing the days by 7 leaves a remainder of 5, which means the MOLAD of Tishrei 5758H occurs on a Thursday. The postponement rules do not apply for this timing of the molad and so Rosh Hashanah 5758H will begin on Thursday.

The time of the MOLAD for Tishrei 5759H is

2,103,082 days; 12 hours; 1005 parts.

Dividing the days by 7 leaves a remainder of 2, which means the MOLAD of Tishrei 5759H occurs on a Monday. The postponement rules do not apply for this timing of the molad and so Rosh Hashanah 5759H will begin on Monday.

Taking the days to 5758H away from the days to 5759H leaves 354.

This means that the length of year 5758H is 354 days. And from this information it is now possible to layout, not only all of the calendar details for 5758H, but also all of the religious details that are calendar dependent, such as the occurrences of the Holidays, the Torah portions for any given day, the set of psalms to be read each day, and so on.

The Tekufot of Reb Shmuel are prescribed in accordance to a completely different set of astronomical parameters, and so require additional arithmetic in order to be mapped onto the Hebrew calendar. This arithmetic, among other things, governs the addition or omission of certain liturgical phrases in such prayers as the Amidah.

The Constant Annual Period

The annual calendar period which begins on the first day of the 29th day month of Adar and ends with the 29th day of Heshvan forms a constant period of 265 days. It is within that period that may be found all of the biblically ordained festivals such as Pesach, Shavuot, Rosh Hashanah, Yom Kippur, Sukkot, and Shemini Atzeret.

The period of time beginning with the first day of Pesach on Nisan 15th up to and including Shemini Atzeret which occurs on Tishrei 22nd is exactly 185 days long.

The period of time from the traditional first day of the vernal equinox which is normally March 21st up to and including the traditional day of the autumnal equinox, usually September 21st, is also exactly 185 days long.

It would be interesting to know whether or not these two periods of time are the same length merely by coincidence.

It is to be noted that the starting day of the constant annual calendar period is fixed by the first day of Tishrei for the immediately following Hebrew year and not from the day of Rosh Hashanah for the current Hebrew year.

The Keviyot - Species of the Hebrew Year

The years of the Hebrew calendar can be laid out in exactly 14 different ways. This is due to the calendar arithmetic.

Each one of these layouts is described uniquely by the week day for Rosh Hashanah of that particular year and by that particular year's length. Each of these layouts is known as a "keviyah" or species.

If a year length is 353 or 383 days, the year is called "haser", i.e., "deficient", because a day is taken away from the month of Kislev. This keviyah is denoted by the Hebrew letter "het".

If a year length is 354 or 384 days, the year is called "kesidrah", i.e., "regular", because none of its months are changed. This keviyah is denoted by the Hebrew letter "chof".

If a year length is 355 or 385 days the year is called "shalem", i.e., "abundant", because a day is added to the month of Heshvan. This keviyah is denoted by the Hebrew letter "shiyyen".

A third Hebrew letter is sometimes added to the first two which represents the day of the week for the first day of Pesach in that year.

The 14 Keviyyot

The 14 possible calendar layouts are derived from the fact that if Hebrew years begin on:

Mondays then they can have **353, 355, 383, or 385** days
Tuesdays then they can have **354, 355, 383, or 384** days
Thursdays then they can have **354, 355, 383, or 385** days
Saturdays then they can have **353, 355, 383, or 385** days.

Year Type Sequences

The calendar arithmetic develops the following pair-wise sequence of Hebrew years.

By definition, a leap year cannot immediately follow any other leap year.

Regular years can not follow regular years and neither can deficient years follow deficient years. However, abundant years can be followed by abundant years.

Regular leap years are always followed by abundant years of 355 days.

The Hebrew Calendar Repetition Cycle

The 19 year cycle does not cause the Hebrew calendar to repeat itself every 19 Hebrew years.

For one thing, no specific demands are made as to what the length of the years ought to be for the 1st 2nd 3rd, etc. years other than whether or not these require the additional leap month.

Moreover all periods of 19 Hebrew years can be 6938, 6939, 6940, 6941, or 6942 days each. As none of these values are exact multiples of 7, it follows that no two consecutive periods of 19 years can begin on the same day of the week. Hence, the Hebrew calendar clearly does not repeat itself after every 19 years.

Incidentally, calendar arithmetic indicates that the 19 year calendar cycles cannot have the length of 6938 days.

At one time, some authorities suggested that the calendar would repeat itself after every 13 cycles of 19 years - once every 247 years. However, simple arithmetic shows that the 247 year cycle is short by 905 parts (about 50 minutes) in order to be a full repetition.

The true calendar repetition cycle actually requires 689,472 Hebrew years, which is 36,288 cycles of 19 years.

Minor note on BAHARAD

After the Hebrew year 1 (on Monday, September 7, -3760g) the Molad of Tishrei will next occur at Baharad for the following Hebrew years

117,358H	04 Jan 113,599g
308,063H	16 Apr 304,306g
498,768H	26 Jul 495,013g
689,473H	04 Nov 685,720g

Of these 4 times, only the year 689,473H leaves a remainder of 1 when divided by 19. Therefore, it is the very first year of a 19 year cycle and as such marks the repetition of the calendar as at year 1H.

Please notice that Rosh Hashanah is seen to be occurring over this time span in seasons that appear to be anything but autumn and also that the differences between the Hebrew years and the Gregorian years are NOT 3761.

The Accuracy of the Hebrew Calendar

It is a myth to look upon the Hebrew calendar as some kind of celestial clock capable of keeping the Jewish holidays in their season.

The accuracy of the Hebrew calendar is fixed by the value of the mean lunation period coupled to the 19 year cycle of 235 lunar months.

That leads to an average Hebrew year length of 365.2468 days.

The mean tropical solar year is approximately 365.2422 days.

Hence, the average Hebrew year is slower than the average solar year by about one day in every 216 years. That means that today, we celebrate the holidays, on average about 8 days later than did our ancestors in 359g at the time that the fixed calendar rules were published.

Should no Hebrew calendar reform take place, then over the next few millennia all of our holidays will have drifted out of their appropriate seasons and Pesach could theoretically be observed in winter.

The Accuracy of the Gregorian Calendar

The actual repeatable cycle of the Gregorian calendar is 400 Gregorian years. Hence, the average Gregorian year is 365.2425 days long.

That means that the Gregorian calendar is slower than the mean tropical solar year by about 3 days in every 10,000 years.

So it too, if left unchecked, will cause its dates to travel the seasons.

The Relative Rate of the Hebrew Calendar

The above mean values indicate that the average Hebrew year is slower than the average Gregorian year by about 1 day in every 231 years.

In modern terms it simply means that Rosh Hashanah cannot occur any earlier than September 5, which last happened in 1899g and will next occur in 2013g. It also means that Rosh Hashanah cannot occur any later than October 5, which last happened in 1967g and will next occur in 2043g.

After the year 2089g, Rosh Hashanah will not be able to occur any earlier than September 6.

When Rosh Hashanah advances to a new day in the Gregorian calendar, it always does so in the 9th year of the 19 year cycle.

The 3761 Myth

This next point is rarely noticed by those who pursue the mapping of Hebrew dates onto Gregorian dates. This is primarily due to the fact that most such exercises are done for very limited periods of time, usually less than 10,000 years.

We are accustomed to determining the Hebrew year at Rosh Hashanah by adding the "constant" 3761. For example, by adding 3761 to Gregorian 1996 we get Hebrew 5757.

If we assume, for purposes of formal calculations, that the rules for both the Gregorian and the Hebrew calendar remain fixed indefinitely, then the assumption of the "constant" 3761 can be seen to be formally incorrect over indefinitely long time. That value can actually be seen to be decreasing over unrealistically large periods of time at the rate of 1 year in approximately every 84,500 Gregorian years.

by the year	the value will begin to be
22,203g	3760
106,716g	3759
191,305g	3758

I'll agree that this information is of absolutely no practical value for virtually everybody, except the computer programmer who runs his little calendar algorithm past the 22,203g mark and is led to believe that his program has some kind of weird bug because the difference between the Hebrew and the Gregorian years is not 3761.

However, this very unexpected phenomenon can easily be traced back to the relative speeds between the Hebrew and Gregorian calendars.

The Gregorian calendar is faster than the Hebrew calendar and so completes its years just a little bit more quickly, thereby increasing its years faster than the Hebrew calendar.

I have not yet found other reference to this non-intuitive fact, but believe that the above results are reasonably correct.

The Gauss Pesach Formula

The famous mathematician Karl Friedrich Gauss (1777-1855) developed a formula which calculates the Julian date for the first day of Pesach for any Hebrew year "A". Since Pesach and Rosh Hashanah are exactly 163 days apart the Gauss formula can be used to calculate the Julian date of Hebrew year "A+1".

Some Calendar Frequencies

Given that the full Hebrew calendar cycle is 689,472 years, it is possible to accurately determine the frequency of postponements, the occurrences of Rosh Hashanah, and other calendar related statistics.

The Most Popular Rosh Hashanah Start

An old Jewish tradition suggests that Tuesday is a good day because it was twice blessed at Creation. (See Genesis 1:9-13). Hence, it should follow that Tuesday would be the most popular day on which to start Rosh Hashanah. Amazingly, it ranks a very poor 4th place among the 4 permissible start days of the week.

In the full calendar cycle Rosh Hashanah begins on

Weekday	No. of Times	Frequency
Thursday	219,831	31.9%
Saturday	196,992	28.6%
Monday	193,280	28.0%
Tuesday	79,369	11.5%

Moreover, Yom Kippur can never occur on a Tuesday!

However, all is not lost. Even though Jewish tradition suggests that Pesach took place on a Thursday, it is Tuesday that is the most popular start day for Passover!

The Postponement Frequencies

Over the full Hebrew calendar cycle:

- 268,937 (39.0%) occurrences of Rosh Hashanah are **NOT** postponed.
- 323,824 (47.0%) occurrences of Rosh Hashanah are postponed by 1 day.
- 96,711 (14.0%) occurrences of Rosh Hashanah are postponed by 2 days.

- 295,488 (3/7) occurrences of Rosh Hashanah are postponed due to the Lo Adu rule.

- 98,496 (1/7) occurrences of Rosh Hashanah are postponed due molad zakein.

- 22,839 (3.31%) occurrences of Rosh Hashanah are postponed due to GaTaRad. These have been advanced into the 354 day years beginning on Thursdays.

- 3,712 (0.54%) occurrences of Rosh Hashanah are postponed due to BeTU'TeKaPoT. These have been advanced into the 383 day years beginning on Thursdays.

- And only 14 different calendar layouts (keviyyot) are needed.

Hebrew Year Length Frequencies

Over the full Hebrew calendar cycle:

- 353 day years occur 69,222 (10.0%) times.
- 354 day years occur 167,497 (24.3%) times.
- 355 day years occur 198,737 (28.8%) times.
- 383 day years occur 106,677 (15.5%) times.
- 384 day years occur 36,288 (1/19) times.
- 385 day years occur 111,051 (16.1%) times.

It is to be noted that the 355 day year is the most frequently occurring type of year, while the 384 day is the least frequently occurring type of year.

Not only do 384 day Hebrew years only begin on Tuesdays, but they occur exactly 1/19 of the time.

The Debatable Molad Zakein Rule

The following arithmetical result is based on the author's personal computer simulations of the Hebrew calendar and no other reference source known to him. It appears to be correct to the best of his knowledge.

The calculation rule referred to as "molad zakein" causes Rosh Hashanah to be postponed to the next allowable day should the time of the molad of Tishrei be noon or later. (i.e. 18h or more).

This rule has been the subject of considerable puzzlement and debate among scholars, some of whom have questioned whether or not it was actually rooted in R. Zera's dictum found in the Talmud tractate Rosh Hashanah 20b.

Most of the references to the molad zakein rule imply that the rule has something to do with the visibility of the new moon on Rosh Hashanah, possibly over Jerusalem.

Calendar arithmetic, however, suggests a more compelling but entirely different functionality for this rule.

According to the arithmetic, the closest to the 2nd day of any month that any molad can occur is 36 and 5/9 minutes. This maximum time theoretically first occurs on the first day of Shevat in the Hebrew year 128,459H (124,700g).

By removing the constraints of the molad zakein rule, the calculated time of the molad is seen to exceed the first day of some months by as much as 5 hours, 23 and 4/9 minutes, which by no coincidence is exactly 6 hours later than its current maximum value.

So it appears that the most compelling reason for this rule appears to have been missed by a lot of scholars. This rule appears to have been designed to ensure that the ***calculated*** time of any molad never exceeds the first day of any month.

Support for this personal view was found by coincidence on page 37 of Wolfgang Alexander Shocken's book "The Calculated Confusion of Calendars..." in which he noted under the topic of the "molad zakein" rule that

The calendar makers wanted to make sure that no month would begin before the actual setting in of the New Moon.

It is unfortunate that Shocken did not explain how he came to that particular correct conclusion. Perhaps he felt that the matter was obvious and therefore would be an easy task for his readers to solve.

Although not immediately apparent, it can be shown if the leap month is placed prior to the month of Heshvan then there is no need whatever for the Molad Zakein rule.

As the mathematics of the situation are not very complex, it is almost certain that the ancient calendar mathematicians were aware of these facts.

The Meir-Saadia Calendar Controversy

The last great debate over the molad zakein rule began in 4681H (920g) between the two giant scholars of the time: Aaron ben Meir of Palestine and Saadia ben Yosef of Babylon.

Ben Meir proposed that the value used for the molad zakein rule be augmented by 642 parts (35 minutes; 40 seconds).

This additional time to the rules meant that the 2 day Rosh Hashanah postponements, which would otherwise have been required for each of the years 4683H (922g) and 4684H (923g), would not be invoked. In turn it meant that the ben Meir rule changes would cause all of the major Jewish festivals in 922g and 923g to be celebrated two days earlier than otherwise.

Ben Meir's proposed calendar change was met with exceptionally vigorous opposition from Saadia ben Yosef (later known as Saadia Gaon). As a result - according to some historical records - during the years 922g and 923g, those parts of the Jewish world which accepted ben Meir's rulings actually did celebrate the holidays of Pesach, Shavuot, Rosh Hashanah, Yom Kippur, and Sukkot two days earlier than the rest of their communities.

Calendar arithmetic points to an interesting possibility as to why ben Meir would have chosen to proclaim his calendar changes in the year 922g.

First, his proposals would have taken effect for the years 922g, 923g, and also 927g. The next time that his changes would be seen would be 181 years later in the year 1108g and it would have only been for that year. Immediately after that, the new rule would have taken effect in the years 1330g, 1334g, and 1335g.

Secondly, the impact of the ben Meir changes occur very infrequently. For example, between the years 900g and 2300g only 20 different years are seen to have their holiday schedules altered due to the ben Meir rule modifications.

So it seems that ben Meir's choice of 922g seized a priceless opportunity to have the suggested changes very much impressed during his own lifetime.

By one of these intriguing coincidences, under the fixed calendar rules, 922g actually marked the first time in the fixed calendar's history that the latest possible date for Pesach and Rosh Hashanah had advanced once again by one day. Rosh Hashanah that year was scheduled for October 1.

Perhaps, among other things, Saadia might have known and wanted to cherish that particular historical moment.

In his classic book *Saadia Gaon: His Life and His Works*, (1926), Henry Malter suggested on page 80

Another, more acceptable explanation is that ben Meir's real purpose was to reduce the number of postponements provided for in the accepted calendar.

Calendar arithmetic does show such a reduction. Applying the Ben Meir rules, we find that the total number of postponements over the full calendar cycle drops from 420,535 to 410,775 for a total of 9,760, which is a 1.42 percent reduction.

It does not take much effort to realize that if you remove the postponements for the period of time between 18h and 18h; 642p you also remove a certain number of postponements. Ben Meir appears to have been far more skilful than that and calendar arithmetic does lead to a far different suggestion.

By adding 642 parts to the molad zakein rule, ben Meir came to within 50 seconds of the maximum value needed to ensure that the result of the molad calculation would never exceed the end of the first day of any month. In other words, ben Meir had sought to optimize the time that would be permitted to wait for the molad of Tishrei before declaring the requisite postponement.

Did ben Meir know the actual maximum value or think that he had actually found that maximum value?

Within ben Meir's lifetime, the next opportunity for his new rules to prevent the traditional postponement of Rosh Hashanah would have been 4688H (927g). However, no documents appear to exist which would have indicated another 2 day split in the observances of Rosh Hashanah.

To date, all scholars of the issue appear to have concentrated almost entirely on what appeared to be the political issues of the debate. Apparently, none of these scholars was aware – or chose to heed –the issues surrounding the calendar's arithmetic. As a result, they all essentially missed the key contribution to the calendar that ben Meir had proposed, which was the optimization of the molad zakein rule.

By concentrating on the political issues rather than on the technical merits of this debate, historians failed to reconstruct the calendar science which led ben Meir to choose a value that had come to within 15 parts of the maximum allowable quantity. That is most unfortunate, since such a study could have given us a much better feel for ben Meir's genius with our calendar's calculations.

Scholars today are split on the issue as to whether or not there was a "winner" in this calendar quarrel. After the year 4688H (927g), the next time that the ben Meir rules would have caused a split in the traditional Rosh Hashanah timing would have been 4689H (1108g), 181 years later. This time, it would have led to a one day split.

So from the calendar arithmetic perspective, it seems that the debate may have died off from the crush of 181 years of medieval Jewish history. And, it also seems that the debate very significantly halted any further progress in the science of the Hebrew calendar.

Hebrew Calendar Improvements

The Meir-Saadia confrontation of 920g was not about the accuracy of the calendar. Rather it was about a change which would have optimized the time permitted before the molad zakein rule would take effect.

Since then, no changes have been made to the calendar. However, there have been a number of suggestions for its reform so as to make it more astronomically accurate.

Arithmetically, it is quite possible to improve the difference between the average Hebrew year and the known average solar year.

In his book ***Rabbinical Mathematics and Astronomy*** W. M. Feldman suggested on page 208 a Hebrew calendar of 334 years in which the first 17 cycles of 19 years would remain the same. There would be a left over period of 11 years whose leap year distribution would be the same as it is now. After those 11 years the next cycle of 334 years would begin.

Feldman believed that this would make the Hebrew calendar accurate to within one day in 12,500 years.

This change in the calendar cycle does not affect any of the known religious requirements of the calendar. But it is only an arithmetical change and so suffers from the drawback of not allowing for some method of also introducing the changes that are always taking place in the astronomical parameters that at one time were believed to be eternal.

Unfortunately, it is unknown when the Hebrew calendar will one day be improved so as to more accurately maintain the holidays in their proper seasons.

The 120 Hebrew Year Spans

Since Moses is said to have lived exactly 120 years, considerable importance has traditionally been attached to the length of such life spans.

Calendar arithmetic reveals that any 120 Hebrew years as measured from Rosh Hashanah to Rosh Hashanah can have either:

43,822 days; 43,823 days; 43,824 days; 43,825 days;
43,851 days; 43,852 days; 43,853 days; 43,854 days; or 43,855 days.

The shortest possible period of 120 Hebrew years is 43,822 days long, while the longest period is 43,855 days long. Hence the shortest period varies from the longest possible 120 Hebrew year period by only 33 days!

In the full calendar cycle, the longest period of 120 Hebrew years begins on only 6,209 Rosh Hashanah's, that is, on only 0.9% of all the new years possible.

Between the years 1800g and 2100g, only the years 5676H (1915g) and 5774H (2013g) could be found to begin these periods of 43,855 days. Incidentally, 5774H (2013g) will begin on September 5, which is the earliest possible Gregorian date for the first day of Rosh Hashanah in our times.

As the longest period of 120 Hebrew years is an exact multiple of 7, that is, 7 times 6265, the 121st Rosh Hashanah will always begin on the same day of the week begun for that 120 year period.

By one of these unbelievable coincidences, not only do all of the Rosh Hashanah's which begin the longest 120 year periods start on Thursday, and inaugurate 385 day Hebrew years, but so does the very last year of each of these spans. The 121st years following these spans also begin on Thursdays, and are all 354 days long.

It is to be hoped that some mathematically inclined individual will one day try to figure out why this is so...

BIZ A HUNDERDT UND ZWANZIG!

It is a highly beloved Jewish tradition to wish each other "biz a hunderdt und zwanzig", which is the Yiddish idiom meaning "may you live until 120 years of age."

Now, the shortest possible period of 120 Hebrew years is 43,822 days long, while the longest period is 43,855 days long. Hence the shortest period varies from the longest possible 120 Hebrew year period by 33 days!

Since the shortest 120 Hebrew year period is 33 days less than the longest such span, and in order not to deny anyone a single precious day of life, it is now absolutely necessary to wish each other...

May you live THE LONGEST POSSIBLE 120 years!

Additional Resources

Convert Hebrew dates to Gregorian dates (and vice versa) using
Alan D. Corre's *Hebrew - Gregorian Calendar*

Shabbat Candle Lighting Times in Major Cities
Avrom Finkelstein's Candle Lighting Times

Modern Lunar Phase Time Tables
Fred Espenak's Lunar Tables

This is an interesting experience in Jewish Time
Robin Treistman's *This Month In Jewish History*

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Editor's Note: Any inaccuracies resulting from my edits of grammar and syntax from the original work are solely my own and may not be reflective of the Author's original intent.