The Enduring Usefulness of the Tur's 247-Year Calendar Cycle

(Iggul of Rabbi Nachshon)

By: DOV FISCHER*

Heinrich Graetz in *History of the Jews* writes:[1]

> Gaon Nachshon ben Zadok of Sora (881-889) made himself famous through his discovery of a key to the Jewish calendar. He found that the order of the years and the festivals repeat themselves after a cycle of two hundred and forty-seven years, and that the forms of the years can be arranged in fourteen tables. This key bears his name; it is known as the cycle of Rabbi Nachshon.

1. The *Tur*'s Tables – Introduction and Background

In *Tur, Orach Chaim* after *Siman* 428 there appears a table with 13 columns (plus two label columns) and 19 rows. Each column represents the 19 years of a Metonic cycle with 7 designated leap years.[2] The 13 columns represent the years in 13 successive 19-year cycles, or a total of 247 years. Each of the 247 boxes provides two basic pieces of data for each year:

- The **weekday** of the first day of Rosh Hashanah; and
- The **number of days** in the year.

The *Tur* (who lived 1270-1340) further indicates that the 247-year cycle is valid for the following four 247-year cycles and beyond:

---

1   Volume III (JPS, 1891/1967), 179.
2   The term is named after Meton of Athens who discovered that 19 solar cycles correspond to 235 lunar cycles. See also *Ibn Ezra, Parshas Bo* (Exodus 12:2).

Dov Fischer is professor and department chair of accounting at Brooklyn College. He attended the Talmudical Yeshiva of Philadelphia, Yeshiva Torah Vodaath, Yeshiva University, and holds a Ph.D. from University of Colorado at Boulder.

1. 247 years from 5055 AM (*anno mundi* - creation year) or Rosh Hashanah 1294 CE to 1540 CE.[3]
2. 247 years from 1541 CE to 1787 CE.
3. 247 years from 1788 CE to 2034 CE (we are currently in the last 19-year cycle of this 247-year cycle).
4. 247 years from 2035 CE to 2281 CE.
5. And the 247-year cycle repeats forever.

<div align="center">לוחות העיבור</div>

													פ/מ	#
בח	הכ	בש	זש	הכ	בש	זח	גכ	זש	הש	בש	זש	הכ	פ	א
הכ	בש	זש	הכ	בח	בש	זש	גכ	זש	הכ	בש	זח	הכ	פ	ב
בש	זש	הח	בח	זח	גכ	זש	הש	בש	זח	גכ	בח	הש	מ	ג
בש	זח	גכ	זש	הכ	בש	זש	הכ	בח	הכ	בש	זש	הכ	פ	ד
גכ	זש	הש	הכ	בש	זש	הכ	בח	הכ	בש	זש	הכ	בש	פ	ה
גכ	זש	הש	בש	זח	הח	בח	הש	בש	זש	הח	בח	זח	מ	ו
בש	זש	הכ	בח	הש	גכ	זש	הכ	בש	זח	גכ	זש	הכ	פ	ז
זח	הח	בח	הש	גכ	זש	הח	בח	זח	גכ	זש	הש	בש	מ	ח
הש	גכ	זש	הכ	בש	זח	גכ	זש	הכ	בש	זש	הכ	בח	פ	ט
גכ	זש	הכ	בש	זח	גכ	זש	הכ	בש	זש	הכ	בח	הש	פ	י
זש	הח	גח	זח	גכ	זש	הש	בש	זח	הח	בח	גכ	זש	מ	יא
זש	גכ	זש	הכ	בש	זש	הכ	בח	הש	גכ	זש	בש	זש	פ	יב
הכ	זש	הכ	בש	זש	הכ	בח	הש	גכ	זש	הכ	בש	זח	פ	יג
בח	הש	בש	זח	הח	בח	הש	גכ	זש	הש	בש	זח	גכ	מ	יד
זש	הכ	בח	הש	גכ	זש	הכ	בש	זש	הכ	בח	הכ	בש	פ	טו
הכ	בח	הש	גכ	זש	הכ	בש	זח	הכ	בח	הכ	בש	זש	פ	טז
בח	הש	גכ	זש	הש	בש	זח	גכ	בח	הש	בש	זח	הח	מ	יז
זש	הכ	בש	זח	הכ	בח	הכ	בש	זש	הכ	בש	הש	נכ	פ	יח
הש	בש	זח	גכ	בח	הש	בש	זש	זח	הח	בח	זח	גכ	מ	יט

Above is the *Tur's* 247-year table. The first column on the right is the year within the 19-year cycle. The next column indicates whether the year is regular (פ-פשוטה) or leap (מ-מעוברת). The 3rd column from the right, which is the first column of data, describes the years (beginning at Rosh Hashanah):

1294, 1541, 1788, 2035 (first line);
1295, 1542, 1789, 2036 (second line);
1296, 1543, 1790, 2037 (third line).

The above table contains 19 lines (or rows) and 13 columns:

---

3   This author finds it easier to relate to world history using secular dates, and will thus use secular dates except when the context requires creation years.

Line 1 in the 3rd column from the right indicates that the first day of Rosh Hashanah is on a Thursday (ה), and it is a normal-length year of 354 days (**כ-כסדרן**).

Line 2 in the 3rd column from the right indicates that the first day of Rosh Hashanah is on a Monday (ב) and it is a deficient year of 353 days (**ח-חסר**).

Line 3 in the 3rd column from the right indicates that the first day of Rosh Hashanah is on a Thursday (ה) and it is an abundant year (**ש-שלם**) with 385 days. Line 3, the 2nd column from the right, indicates a leap year (**מ-מלא**).

1.1. The *Mishnah Berurah*, the *Peri Chadash,* the *Levush,* and the Term *Iggul* of Rabbi Nachshon

The *Mishnah Berurah, Biur Halachah* 427:1 discusses the *Tur*'s tables:

כשראש חודש וכו' - ועיין סדר הקביעות בטור והנה בטור סידר הקביעות שבכל י"ג מחזורים קביעותם שוה והוא מה שקראו הלבוש עיגול דרב נחשון גאון אך הלבוש כתב ע"ז המון המעברים חושבים י"ג מחזורים בשוה אבל כשתדקדק היטב תמצא שאינו כן עכ"ל וכן העתיק בהגהת ב"א מספר יסוד עולם מאמר רביעי פרק יו"ד בסופו כי מה שסוברים שכל הי"ג מחזורים הם בשוה הוא רק ברוב השנים אבל לא בכולם ולכן אין לסמוך על עיגול זה של י"ג מחזורות עכ"ל ע"ש באריכות וכן בפר"ח השיג על הטור ופירש השנים האיך עולה לפי חשבון וכמ"ש בספר תקון יששכר והזהיר מאוד מאוד שלא לשמוע לסדר הקביעות של הטור על שנים ידועות ע"ש וכן מצאתי עוד בשאר ספרים אך לעניננו אין שום נ"מ מזה כי על שנים שעברו עד הנה מה דהוה הוה וגם באמת כבר נתקן באיזה מקומות בלוח של הטור גופא כפי מה שהגיה הפר"ח ועל שנת תרס"ב תרס"ג תש"ז תש"ח כתבתי לקמן איך הוא הקביעות באמת עי"ש ויתר השנים משך רב כמעט עד שנת תתמ"ז כתובות בלוח הטור כהוגן כפי מה שנראה מפר"ח שלא הגיה עליו [אם לא שימצא עוד איזה קלקול בדפוס וכמו שראיתי בפר"ח כתוב שם על שנת תתקנ"ג סימן בח"ג והוא טה"ד וצ"ל זח"ג וכן על שנת תשמ"ג כתוב בדפוס לעמבערג בש"ז והוא טה"ד וצ"ל ז"ש כמו בטור והוא זש"ג אח"כ מצאתי כן בדפוס ישן] ואין לנו לדאוג כ"כ יותר כי בודאי בעת ההיא וגם הרבה קודם יהיה הגאולה ונקדש ע"פ הראיה:

The controversial claim printed in the *Tur* is that the cycle repeats itself after 247 years. For example, the years starting in autumn 1294, 1541, 1788, and 2035 CE will each have 354 days and the first day of Rosh Hashanah will be Thursday. The years 1295, 1542, 1789, and 2036 CE will

each have 353 days and the first day of Rosh Hashanah will be Monday. The years 1296, 1543, 1790, and 2037 CE are leap years with 385 days, and the first day of Rosh Hashanah will be Thursday.

The *Peri Chadash* is the harshest critic of the 247-year cycle.[4] He shows that the cycle does not repeat itself perfectly. Pre-dating the *Peri Chadash*, the *Levush* also warned that the 247-year cycle does not repeat itself perfectly, but their attitude towards the 247-year cycle differed.[5] The *Peri Chadash* warned against the use of 247-year tables and instead provides a series of 19-year tables until 2239 CE (6000 creation year) but not in the format of 247-year cycles. In contrast, the *Levush* provides data for a single 247-year cycle (1560-1806 CE) with the following preface: "Here is the *Iggul of Rabbi Nachshon Gaon,*" and the following post-script: "The masses of calendar-makers call it an *Iggul* and claim that the cycle repeats itself forever, but when you examine carefully you will find that this is not so. Nevertheless, I wrote so you should have readily available at least the setting of 247 years."[6] Reading the *Mishnah Berurah*, one gets the impression that the *Levush* was discussing the *Tur*'s tables, but the *Levush* never mentions the *Tur*. In fact, the *Tur*'s second 247-year cycle (1541-1787) covers a period slightly different than the 247-year cycle provided by the *Levush* (1560-1806).

While the *Mishnah Berurah,* the *Levush,* and the *Peri Chadash* all agree in substance that the 247-year tables cannot be relied upon to repeat themselves in perpetuity, they differ in their appreciation of the concept of a 247-year table. The *Peri Chadash* warns against any use of such table, while the *Mishnah Berurah* and the *Levush* appear to encourage the use of such tables but with the proper precautions.

The *Mishnah Berurah*'s mild position on the 247-year tables is presaged by the *Chatam Sofer*. Responding to a letter which complained about

---

4   *Peri Chadash* commentary to *Shulchan Aruch, Orach Chaim* 428, authored by Rabbi Hezekiah da Silva (c.1656-1695). *Peri Chadash* was the earliest major Sephardi commentary on the *Shulchan Aruch* still used today. He was born in Italy and studied in Jerusalem under Rabbi Moshe Galanti, followed by a stay in Amsterdam. On his return to Jerusalem through Egypt, his publication *Peri Chadash* caused a sensation. He was buried in the Mount of Olives after a short, turbulent life.

5   The *Levush* was authored by Rabbi Mordechai Yaffe (1530-1612). He was born around the same time as Rabbi Moshe Isserles (the Rema) and was the latter's student, though he outlived the Rema (who passed in 1572) by several decades.

6   *Levush Hachur, Orach Chaim* 428.

confusion in calendars, the *Chatam Sofer* directs the inquirer to the published table in the *Tur* and the *Peri Chadash*'s emendations.[7]

והנה מ"ש מעלתו שנכשלו בקביעות השנים תמהתי כי הקביעות של כל
השנים העתידי' כבר נדפסו בטא"ח ובהגה' פרי חדש וכיון שמדפי' הלוח
יעיי' בקביעות השנה שם שוב יחפש בי"ד שערים ר"נ[8] שבספר עברונות
וימצא מבוקשו

    The *Chatam Sofer* accepts the use of the *Tur*'s 247-year table, subject to corrections to individual years. The *Chatam Sofer*'s reference to both the *Tur* and the *Peri Chadash* is noteworthy. The *Peri Chadash* saw the 247-year table in the *Tur* as a dangerous format which invites misunderstanding and errors. *Peri Chadash* did not emend the *Tur*'s tables but provided substitute tables which discarded the 247-year format. The *Chatam Sofer* obviously agreed with the *Peri Chadash*'s substantive, technical corrections, but nevertheless appreciated the 247-year format of the *Tur*. Similarly, *Mishnah Berurah (Biur Halachah* 427:1) accepts the corrections of the *Peri Chadash* but endorses the continued use of the 247-year table.

    In summary:

- The *Peri Chadash* is the harshest critic of the 247-year table and believes that any use of such tables "departs from life itself"
- The *Levush, Chatam Sofer,* and *Mishnah Berurah* recognize that the 247-year cycle does not repeat itself perfectly, but they condone the use of 247-year tables, subject to proper fact-checking to the *Molad* and *Kvius* rules.

    Later in the paper, I will explore why the latter condoned the 247-year format, in contrast to the *Peri Chadash*. On the face of it, the *Peri Chadash* is right in that the 247-year tables give the mistaken impression that the cycle repeats itself perfectly in perpetuity.

1.2. The "*Perush*" on Rambam, *Hilchot Kiddush Hachodesh*

The *Mishnah Berurah* attributes the term *Iggul of Rabbi Nachshon* to the *Levush*. There is a widely published unattributed "*Perush*" on the *Rambam Hilchot Kiddush Hachodesh (HKH)*. In his short introduction to his *Perush* on *HKH*, the author identifies himself as Ovadiah ben David ben Ovadiah but provides no other information about himself. In the *Perush* to chapter 8:10 of the *Rambam*, the *Perush* describes the mechanics of the 247-year

---

[7]   *Collected Responsa,* Part 6, number 35. Authored by Rabbi Moshe Sofer (1762-1839).

[8]   Rabbi Nachshon.

cycle (which we will describe below) and states *"this is the Iggul of Rabbi Nachshon of blessed memory, which consists of 13 cycles of which they say it repeats continuously until the Kohen will stand at Urim VeTumim (i.e. arrival of Messiah). Be warned, not to err, for this is not so."* Later in the discussion, the *Perush* dates his year of authorship as 1324, making him a contemporary of the *Tur*.

1.3. Academic Findings Explain the Lack of Commentary on the *Tur*'s Tables

In 1902, Zvi Hirsch Yaffe and Rafael Gordon, writing in *Hamelitz*, theorized that the Tur did not intend to imply that the 247-year cycle repeats itself perfectly, and that he provided 9 additional columns for 19-year cycles which do not repeat themselves perfectly over the four 247-year cycles. Vidro (2018) researched handwritten manuscripts and early printed editions (incunabula) and found the following:[9]

- Most handwritten manuscripts before the advent of printing indeed had 22 columns rather than just 13 columns, confirming Yaffe and Gordon.
- Early printed versions from 1475 to 1540 contained no tables at all.
- Printed versions from 1540 (Soncino Press of Constantinople) contain the current 13-column format.

The current standard edition of the *Tur* published by Machon Yerushalayim contains the standard 247-year (13-column) table with data corrected for the current 247-year cycle (1788-2034). The footnotes by Machon Yerushalayim acknowledge that the amended data comes from Gordon, and they publish Gordon's 22-column version several pages later. It is noteworthy that the major rabbinic authority in the last century on the *Tur*'s tables (the *Mishnah Berurah*) is studied together with the standard *Tur* edition which was emended with findings originally published in *Ha-Melitz*.

The findings on manuscripts and early prints also explain why there is no *Beit Yosef, Darkei Moshe,* and *Bach* commentary, and only a short snippet from *Perishah* on the *Tur*'s tables. Rabbi Joseph Karo (1488-1575) authored *Beit Yosef* in his youth many decades before he authored the *Shulchan Aruch*. He likely used a pre-1540 printed edition of the *Tur* which contained no tables (neither today's 13-column nor the original 22-

---

9   Nadia Vidro, "Calendar tables in manuscript and printed Arba'ah Turin: Tur Orah Hayyim, chapter 428," *Journal of Jewish Studies LXIX*, No. 1 (Spring 2018), 58-85. See footnotes 61 and 62 for references and links to *Hamelitz*.

column). The *Rema* (Rabbi Moshe Isserles, author of the *Darkei Moshe*) may have had post-1540 editions of the *Tur*, but he conceived of the *Darkei Moshe* (in its final form) as a super-commentary on the *Beit Yosef* which did not comment on the table. Furthermore, *Rema* may have been uncomfortable with the knowledge that pre-1540 editions did not include the table, and so he chose not to comment.

The *Perishah* (Rabbi Joshua ben Alexander HaCohen Falk, also known as *Sema*, 1555-1614) belonged to the first generation which used the post-1540 prints exclusively. This explains why he alone chose to comment, though very briefly. Interestingly, his brief comment is equally valid from the perspective of a 22-column table as for a 13-column table, which he presumably was commenting on.

Notably, the *Levush,* who is near-contemporary with the *Rema* and who is quoted by the *Mishnah Berurah* as the provenance of the term *Iggul of Rabbi Nachshon*, never actually referred to the *Tur*'s tables in discussing the 247-year cycle. Also, his cycle is not synchronized with that of the *Tur*. Vidro (2018) notes that a *Sefer Evronot* with a 247-year reiterative calendar titled "*Iggul de-Rav Nachshon*" was published in Italy in 1561. The *Levush*, who spent time in Italy, may have picked up the nomenclature of *Iggul* from the *Sefer Evronot*. The term *Iggul* does not appear in the *Tur*.

We can speculate as to why the *Bach* chose not to comment on the 247-year tables. The *Bach* (Rabbi Joel Sirkis, 1561-1640) certainly used post-1540 editions of the *Tur* so the question is why did he choose not to comment? The *Bach* is famous for his extensive library of hand-written manuscripts and perhaps also early printed editions. With the knowledge of the inconsistencies between manuscripts, early prints, and post-1540 prints, the *Bach* may have decided to follow in the footsteps of *Beit Yosef* and *Darkei Moshe* and to recuse himself from commenting.

Finally, *Perishah'*s short snippet does imply that he was looking at a 247-year table. However, his language is remarkably prescient and is reminiscent of the expression *Tzadikim ein HaKadosh Baruch Hu mevi chet al yadam*. The *Perishah*'s short comment is that the four 247-year cycles have [some] identical four-year cycles, paraphrasing "for example in the cycles labeled as repeating such as those beginning in 1294, 1541, 1788, 2035." It turns out that this specific 19-year cycle (i.e., the first 19-year cycle in the 247-year cycle) does repeat perfectly over four 247-year intervals according to Gordon's 22-column tables.

For additional academic discussion of the *Iggul*'s provenance, see footnote 94 of J. Jean Ajdler's "A Short History of the Jewish Fixed Calendar: Origins of the Molad" (*Hakirah*, 2015), and Nadia Vidro's "The Origins of the 247-year Calendar Cycle" (*Aleph*, 2017).

2. Mathematical Importance of the 247-year Cycle

Unlike the *Peri Chadash,* who had no use for the 247-year cycle, the *Mishnah Berurah,* the *Levush,* and the *Chatam Sofer* saw value in the 247-year tables. Similarly, the *Levush* provides data for one 247-year cycle despite warning that it does not repeat perfectly. In a similar vein, the above-cited *Perush* on the *Rambam* also goes into the technicalities of the 247-year cycle, even while warning that the cycle does not repeat perfectly.

So, despite the obvious dangers of over-reliance in the case of exceptional years, the *Mishnah Berurah* and *Chatam Sofer* imply that the benefits of a 247-year emended table outweigh the potential dangers of over-reliance. Similarly, printers from 1540 universally adopted the 13-column cycle of 247 years, even though this was never the *Tur*'s intent. Conventional wisdom may have found the 13-column table aesthetic and intuitive, but perhaps there was a deeper wisdom at play.

The 247-year cycle does in fact have mathematical significance in validating the more basic, uncontroversial 19-year cycle. Furthermore, it is useful in tracking the lunar/solar differences in the 19-year cycle. Finally, it can be used as a tool to eventually correct the accumulating lunar/solar differences.

2.1. The 19-Year Metonic Cycle and Its Problem of Fractional Days and (30-day) Months

The 19-year cycle was discovered by the Greeks and Babylonians 2500 years ago. There are 12.36827 lunar cycles for each solar cycle. One way of looking at this is that we require 12 months per year, plus an additional month for 36.827 percent of years. The ratio of 7 to 19 years comes very close to 36.827 percent, but it is off by a small amount. This problem is not solved by the 247-year cycle, but there is another problem that is automatically solved over 247 years.

Lunar cycle	29.53059 days	
Solar cycle	365.24217 days	
Solar/Lunar	12.368**265**	7/19 = 0.368**421**

The problem that is automatically solved is the problem of whole days and the number of Jewish months of 30 days and 29 days. The lunar cycle is 29.53059 days. As the Rambam implies (*HKH* 8:1), this dictates that 53.059 percent of months must be 30 days and the rest must be 29 days. A 19-year cycle has 235 months, including 7 leap Adars. With 235 months it is impossible to get a round number of 30-day months. A related problem is that it is impossible to get a round number of days, as the

number of astronomical days in 235 months is approximately 1/3 of a day short of 6,940 days.

	235	Months		235	Months
times	53.059%	30-day months	times	29.53059	Astronomical days per month
	124.69	30-day months		6,939.69	Days in 19-year cycle

	124.69	30-day months
plus	110.31	29-day months
	235	

In a typical *Machzor* of 19 years (i.e. 235 months) there are 6,940 days and 125 30-day months. Mathematically, this is inconsistent with the lunar cycle which requires 6,939.69 days and 124.69 30-day months. This is not a criticism of the calendar, but a statement of fact that fractional days and months are impossible to implement.

The beauty of the Jewish calendar and the discovery of Rabbi Nachshon is that if we expand the cycle to 247 years or 3055 months (i.e., 13 19-year cycles) there will be some variation in the 19-year cycles. The result is indeed very close to the mathematical lunar calculations and comes very close to solving the problem of whole days and months.

	3055	Months		3055	Months
times	53.059%	30-day months	times	29.53059	Astronomical days per month
	1,620.95	30-day months		90,215.95	Days in 247-year cycle
Actual:					
	1,621	30-day months		90,216	Actual days in 247-year cycle
plus	1,434	29-day months			
	3,055				

To be clear, the 247-year cycle is not a rule like the 19-year cycle. The 247-year cycle does not dictate any adjustments. Rather, it is the *Molad* and *Kviut* rules that ensure that these averages are met, but it takes a 247-year cycle for the averages to manifest.

This explains why the 247-year cycle is called an *Iggul,* whereas the 19-year cycle is called a *Machzor.* The latter term implies perfect repetition, while the former term makes no such claim. The *Iggul* is merely a closing of a loop to show that the *Molad* averages are achieved over 247 years.

The *Mishnah Berurah, Chatam Sofer*, and *Levush* all understood the weaknesses and potential dangers of the *Iggul*, yet they implied that they were not in favor of completely discarding its use. This is in contrast with the *Peri Chadash* who urged the reader to use his 19-year tables only and "he who departs from these, departs from life itself." I am suggesting that the rabbinic authorities understood the importance of the *Iggul* in demonstrating the mathematical validity of the Jewish calendar, which outweighed its potential misuses.

Another potential use of the *Iggul* is that it <u>does</u> repeat itself for 97 percent of years. While the *Iggul* table should not be relied upon blindly, it can be used as a check against errors in *Molad*-based calculations. When the *Molad*-based calculation conflicts with the 247-year table, it is the *Molad* that determines the *Kviut*, but in that case it should be double- and triple-checked.

2.2. Lunar/Solar Errors in the Metonic Cycle

The basic problem solved by the leap year is that one solar cycle is longer than 12 lunar cycles. Uncorrected, this would cause Passover to arrive earlier in the spring each year and into the winter. The solution is the 19-year cycle of 235 lunar cycles which includes 7 additional months. The problem is that 235 lunar months are slightly more than 19 solar years. Over 19 years the leap years over-correct and the lunar cycles jump ahead of the solar cycle. Every 19 years, Passover progresses two hours into the summer. Every 247 years, Passover progresses slightly more than a day into summer.[10]

6,939.60	days in 19 solar years
6,939.69	days in 235 lunar months
(0.09)	Difference in days
(2.10)	Difference in hours

Multiply by 13 cycles (247 years)	
90,214.82	days in 247-solar years
90,215.95	days in 235x13 lunar months
(1.14)	Difference in days

---

10   See *Ibn Ezra, Parshat Bo.*

In the very long term the solution is an obvious one,[11] although I believe I am the first to express it in terms of the 247-year cycle. Just as the leap year helps the lunar cycles catch up to the solar cycle, the omission of a leap year can correct for the over-correction. It turns out that one less leap year every twenty-six 247-year cycles will do the trick.

26 x 247-year cycles (uncorrected)	
2,345,585.22	days in 247x26 solar years (x365.24217)
2,345,614.76	days in 235x13x26 lunar months (x29.53059)
(29.55)	Difference in days

26 x 247-year cycles (with one less month)	
2,345,585.22	days in 247x26 solar years
2,345,585.23	days in 235x13x26-1 lunar months
Virtually zero	Difference in days

We can explain this in a different way which may clarify. Recall that the original problem with the Metonic Cycle is that it does not perfectly conform to the ratio of solar to lunar cycles.

Lunar cycle	29.53059 days	
Solar cycle	365.24217 days	
Solar/Lunar	12.368**265**	7/19 = 0.368**421**

However, by deducting one leap year every 6422 years the leap-year ratio is again perfectly aligned with the solar/lunar ratio.

	Leap years	Total years	Ratio
Basic Metonic Cycle	7	19	0.368**421**
times	x13	x13	
times	x26	x26	
subtotal	2366	6422	0.368**421**
Minus	-1		
	2365	6422	0.368**265**

---

[11] See Rabbi Michael J. Broyde, "A Mathematical Analysis of the Structure of the Jewish Calendar: Perfection as the Enemy of the Very Good," *Hirhurim Musings Torah Journal,* July 2010, 151-174.

3. Conclusion

The *Tur*'s 247-year table is an enigma and, to the *Peri Chadash*, an embarrassment. The printed claim in the *Tur* is that the Jewish calendar repeats itself every 247 years, and this claim is not always true. *Peri Chadash* was the biggest critic and provided alternative tables which discarded the 247-year format. However, *Chatam Sofer* and *Mishnah Berurah* support the use of the *Tur*'s tables, subject to the *Peri Chadash*'s emendations.

The 247-year cycle is attributed to Rabbi Nachshon Gaon by the *Levush*, as well as by the anonymous *Perush* on the *Rambam* two centuries before the *Levush*. Prior research has shown that the *Tur* never intended to claim that the 247-year cycle repeats itself perfectly. The question is why has the 247-year-format proven so popular? After all, the *Peri Chadash* points out that it is dangerous to use such tables that repeat themselves *almost* perfectly.

This study demonstrates that the 247-year cycle validates the actual Jewish calendar as conforming to the theoretical lunar average month of 29.53059 days and 53.059% 30-day months. It is only after thirteen 19-year cycles that this average is achieved. The popular and mistaken notion that the table repeats itself is a side effect of the mathematical cycle which causes the table to repeat itself almost perfectly.

The *Iggul* is fundamentally different than the 19-year *Machzor*. The *Machzor* is a basic technical building block of the Jewish calendar (the other building blocks are the *Molad* and *Dechiyot*). On the other hand, the *Iggul* is the completion of a long-term cycle over which the average monthly days in the calendar conform to the *Molad* and astronomical averages.

Theoretically, the 247-year cycle is also a perfect tool to solve the lunar/solar difference in the long run (over several thousand years). After each 19-year cycle, Passover is pushed two hours into the spring. After 247 years, Passover is pushed into the spring by 1.14 days. If we omit one leap year every twenty-six (26) 247-year cycles, the lunar and solar cycles will be perfectly synchronized and the basic problem with the Metonic Cycle will have been solved. ❧