Jewish Dating Pitfalls and Resources

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Many diverse calendars are in use, or have been used historically, making the correct interpretation of dates difficult. To help remedy this situation, we have been developing and implementing calendrical algorithms over the past 30 years. Below we give some brief historical remarks about calendars (civil, Hebrew, and Islamic), but our primary focus is the problems and pitfalls faced by genealogists in dealing with dates, along with useful resources for date conversion.

Iudaicus computus, omnium qui hodie extant antiquissimus,
articiosissimus, et elegantissimus
[Of all methods of intercalation that exist today,
the Jewish calculation is the oldest, the most skillful,
and the most elegant]
—Joseph Justus Scaliger: *De Emendatione Temporum* (1593)

I. Calendars

There are scores of different calendrical systems employed by societies around the world today; these include calendars in widespread use, like the Gregorian, Hebrew, Islamic, and Chinese, as well as more obscure calendars, such as the Coptic and Bahái, plus many more that are of historical importance such as the Egyptian, Julian, Mayan, Old Hindu, and French Revolutionary. The Jewish Diaspora has resulted in the documenting of births and deaths in such a variety of calendars that the job of the genealogist is complicated indeed!

Unfortunately, information that is sufficiently detailed to allow conversion of dates has been difficult to find for many calendars (such as the Chinese, Hindu and Persian). Published material is often inaccessible, ecclesiastically oriented, incomplete, inaccurate, based on extensive tables, overburdened with extraneous material, focused on shortcuts for hand calculation to avoid complicated arithmetic or to check results, or unavailable in Western languages. At the same time, most existing computer programs are proprietary, incomplete, or

inaccurate—even the (now) nearly universal Gregorian calendar is incorrectly implemented in much software.

To help remedy this situation, we have been developing and implementing calendrical algorithms over the past 30 years. Our involvement began with computer code that provided calendar and diary features within GNU Emacs (a popular text editor) and which engendered a deluge of inquiries and requests from around the globe, among them from refuseniks who were using the freely available program to determine dates of Jewish interest.

Below we give some brief historical remarks about calendars (civil, Hebrew, and Islamic), but our primary focus is the problems and pitfalls faced by genealogists in dealing with dates, along with useful resources for date conversion.

In the text following we refer to various resources by abbreviated name only. Detailed information on all resources mentioned is given in section VII.

II. Civil Calendars

The Gregorian calendar—designed at the end of the 16th century and used today throughout the world—is purely solar in nature. It was instituted by Pope Gregory XIII to replace the Julian (old style) calendar.[1] A papal bull proclaimed that Thursday, October 4, 1582 CE would be followed by Friday, October 15, 1582 in the new-style (Gregorian) calendar. Catholic countries (Spain, Portugal, Italy, and the Catholic states in Germany) switched immediately to the new calendar, but Protestant countries resisted and for the most part adopted it only in the 18th century. (See Figures 1 and 2.) Some countries did not adopt it until the 20th century; for example, Russia in 1918 (thus the "October Revolution" took place in November on the Gregorian calendar!) and Turkey in 1927. Thus even relatively recent documents might refer to Julian dates. An extensive list of dates of adoption of the Gregorian calendar (critical for understanding what a date means) can be found in the *Ephemeris Supplement*.

[1] Gregory was not only responsible for the institution of the revised calendar, but he was also responsible for a bull *Vices eius nos* (September 1, 1577) organizing regular missionizing sermons by apostate Jews that the Jewish community of Rome was forced to attend and subsidize. His bull *Sancta mater ecclesia* (September 1,1584) specified more precise conditions: beadles armed with rods made sure the Jews paid attention and checked that they had not put wax in their ears.
These sermons took place throughout the Papal States and much of the Roman Catholic world, as well as in the church nearest the Jewish quarter in Rome, San Gregorio della Divina Pietá (the front of this church has an inscription in Hebrew and Latin, beside an image of the crucified Jesus, quoting from *Isaiah* 65:2-3, "I have spread out My hands all the day unto a rebellious people, that walk in a way that is not good, after their own thoughts; a people that provoke me to my face continually.").

By universal current custom, the new Gregorian year number begins on January 1. There have, however, been other customs: parts of Europe began the New Year variously on March 1, March 25, Easter, September 1, and Christmas. For example, in England, the commencement of the ecclesiastical year on March 25 in the 16th and 17th centuries means that a date like February 1, 1660, leaves the intended year in doubt. Such confusion led to the practice of writing a hyphenated year giving both year numbers: February 1, 1660–1.

Not all countries use the CE (= AD) year count, though they use the Gregorian calendar. Taiwan, for instance, uses the Gregorian calendar with an era that begins at the founding of the republic in 1911.

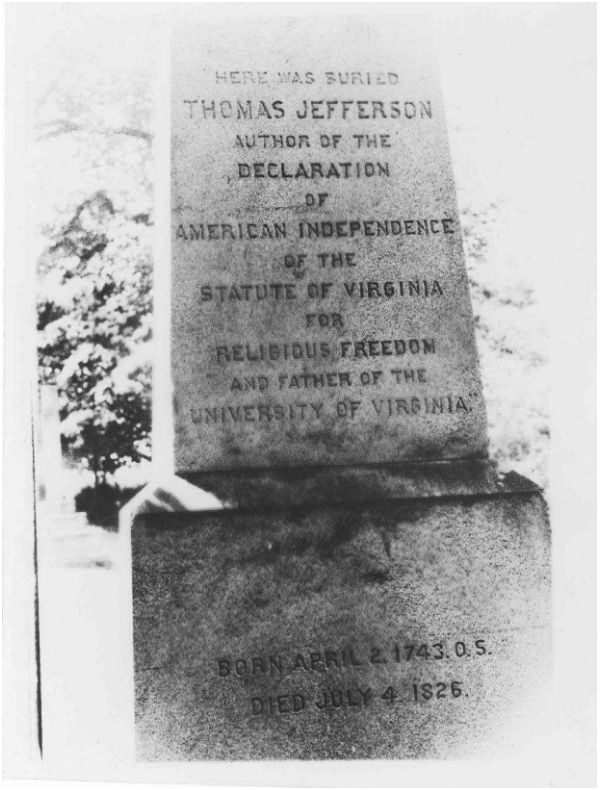


Figure 1: Thomas Jefferson's grave. The date of birth, April 2, 1743, says "O.S." (old style), meaning that it is on the Julian calendar, while the date of death, July 4, 1826, is on the (new style) Gregorian calendar. The changeover in Great Britain and her colonies took place in 1752.

Figure 2: Swedish almanac pages for February, 1712, showing a 30-day month. The Swedish date is on the left, the Gregorian on the right. Friday, February 30 (Swedish) is given as March 11 (Gregorian) = February 29 (Julian). Sweden began a gradual changeover to the Gregorian calendar in 1699, then abandoned the plan, leaving the Swedish calendar one day off from the Julian, an anomaly that was later rectified, as shown here.

III. The Hebrew Calendar

In the Hebrew lunisolar calendar, days begin at sunset, months begin with the new moon, and years are kept in tune with the seasons by the intercalation of a leap month every 2–3 years. In ancient and classical times, the month began with the observation by at least two witnesses of the crescent moon; leap months were added by the Jerusalem authorities as the need arose. The fixed calendar, attributed to the 4th-century patriarch, Hillel II, is based on a mean month of 29d 12h 44m 3 1/3 s and on the 19-year Metonic cycle comprising 7 leap years, each containing 13 months, and 12 years of 12 months. The average year length is 365.2468 days, which is slightly longer than the mean tropical year. On account of the accumulated discrepancy, Passover often occurs nowadays more than a month after the vernal equinox. The fixed calendar also incorporates several rules for delaying the onset of the year, as a consequence of which common years have 353–355 days, leap years have 383–385 days, and Passover never begins on Monday, Wednesday, or Friday. The details of the fixed calendar were finalized by the 10th century.

The Karaite lunisolar calendar is still observation-oriented; the Samaritan calendar is based on astronomical calculations.

In the Bible, months are usually identified by number, beginning in the spring. The current names, of Babylonian origin, were adopted in antiquity. One can find both styles used throughout history.

Since the Middle Ages, the year number has almost always been Anno Mundi, starting with year 1 AM which began on October 7, 3761 BCE (Julian). The historical use of several other "eras of creation" has created much confusion, notably with regard to the date of destruction of the Second Temple in 70 CE Yemenites continued to use the Seleucid Era until their mass emigration to Israel in 1949–50.

When written in Hebrew numerals, year numbers usually omit the millennium. The gravestone in Figure 3 shows one year, 5265 (=1905), given with the millennium, and another, [5]666 (=1906), given without. In the former case, the year number is actually followed by a stylized lamed-pe, signifying "in the [major] era"; in the latter, by lamed-quf, standing for "in the minor era". Note also the not uncommon mistakes of daleth for resh and he, he for heth, and vice-versa.

Occasionally, the year number is indicated as a chronogram, by means of dotted or enlarged letters that add up, numerologically (gematria), to the year number (see Figures 4 and 5).

Letters and epitaphs sometimes refer to holidays or other calendrical events, to the weekly Torah reading, or quote verses from the Torah or prophetic portion. Spier, the *Encyclopaedia Judaica*, and most Hebrew-calendar software provide the necessary data for decipherment. See Figures 5 and 6.

Figure 3: A Jewish gravestone (great-grandparents of E.M.R.) showing typical typographical errors and varieties of Hebrew dates: One year, 5265 (=1905), given with the millennium, and another, [5]666 (=1906), given without. In the former case, the year number is followed by a stylized lamed-pe, signifying "in the [major] era"; in the latter, by lamed-quf, standing for "in the minor era". The Hebrew name of Myer's father, Moshe is mispelled (a resh instead of a he), as is the Hebrew word parkha (a daleth in place of a resh) in Rosa's inscription.

לקהלות הקדש
שמסרו נפשם על קדשת השם
יהי זכרם ברוך

Figure 4: A concealed year (from *Calendrical Calculations*, 3rd ed., Nachum Dershowitz and Edward M. Reingold, 2008). The dots over selected letters indicate the dedication year: התשסז = 5767 a.m. (2006–2007).

הקדמה מהת"ג המחבר זצלה"ה א

ב"ה יום ג' תרומה תרצ"ב לסדר מנרת זהב טהור.

מה נכבד היום שבאו לפני בניי היקרים החריפים ומופלגים שיחיו חיי נחת ובקשו מכני שאתן הסכמה על הספר „גנזי יוסף" על הש"ס מזקינם הרב הגאון הגדול סיני ועוקר הרים הבקי בנגלה ובנסתר כש"ת מוה"ר יוסף אלטר עפשטיין ז"ל בעה"מ ספר „גנזי יוסף" על הפתיחה כוללת של בעה"מ הפרי מגדים ז"ל ונתנו לו אז הסכמות גדולי עולם ועל ראשם כ"ק דו"ז הרב הצדיק הקדוש רבן שכבה"ג מוהר"ר יהושע זצ"ל אבד"ק בעלז וגם בנו ש"ב אדמו"ר הגאון הקדוש צדיק יסוד עולם וכו' מוה"ר ישכר דוב זצללה"ה מבעלזא וכעת בקשו בניי היקרים שאתן להם הסכמתי וגם לעשות הקדמה על הספר הזה והנה לדעתי אך למותר כי די עדותו של כ"ק אדמו"ר הרב הקדוש זצללה"ה מבעלזא שנתן הסכמתו ועדותו שכוונתן לשמים וזאת ראיתי בעצמי בעת שהייתי סמוך על שלחנו שלא מש מתוך אהלה של תורה ממש יומם ולילה הגם שהי' טרוד בצרכי העיר להשיב לשואליו דבר אבל הוא באחת הספרים הקדושים היו מונחים לפניו תמיד ולמד שיעורים בגפ"ת וגם בספרי קבלה הקדושים למד בלילה אחר חצות וכתב החידושים שלו מיד תיכף בשעת הלימוד והי' חסיד גדול ולא דיבר שום דבר בטל ולמד תורה ברבים עם תלמידיו ועם בניו היקרים לא מש פומיה מגרסא אפילו רגע אחד והגאונים הגדולים שהיו בימיו היו אוהבים אותו ופלפלו עמו הרבה הגאון הגדול ר' שלמה קלוגער ז"ל אהבו מאד ודיבר עמו הרבה בהלכה ונתן לו הורמנא ואמר רק לאברך כזה שהוא בקי בש"ס ובפוסקים צריכין ליתן הורמנא ולא לזולתו גם הגאון הגדול מוה"ר יוסף שואל ז"ל נאסינזאהן אבד"ק לבוב השתעשע עמו בהלכות ואמר עליו שהוא מעין מתגבר והוא צנא מלא ספרא גם צדיקי דורנו השתעשעו עמו ברזין דאורייתא וגם מורי הגאון הגדול מוה"ר יצחק שמעלקיש ז"ל אבד"ק לבוב אמר אלי פעם אחת בעת שהייתי אצלו מאיר לעב וויא נעמט מען דיין שווער צינט איך דארף איבערשמיסען א ענין עמוק בנידון עגונה אחת ונתן לי אז עשרה רייניש שאשלח לחותני הה"ג ז"ל שיבוא וכן עשיתי ודפקתי ט"ג ובא והיו אצלי שני ימים ודברו מזה העניין כל השני ימים ושמח מאוד הרב הגאון ז"ל ואמר אז שבירר הלכה הזו לאמתה ושבע עונג רב מזה לכן למותר ליקח הסכמות על זה הספר וגם הקדמה למותר מחמת הוצאת הדפוס וכל מי שילמוד בזה הספר בטח ישבע עונג רב ויתנו לי יישר כח גדול ובפרט שאני נותן המעות ואין בדעתי לעשות מזה מסחר רק לטובת נשמת חותני הה"ג ז"ל אני מדפיס את חידושיו ומבקש אני מכל הלומדים שיקחו את הספר הזה כדי שיוכלו בניי היקרים שיחיו להוציא לאור את החלק השני על הש"ס כי לא נדפס כעת רק עד מסכת כתובות והמחיר יעלה רק כפי החשבון של הוצאת הדפסה. והנני אומר לפעלא טבא יישר יהי רצון שנזכה ללמוד וללמד ולשמור ולעשות מתוך נחת והרחבה וכל מי שיקח את הספר הקדוש הזה בטח יהי' לעונג ולשמירה בתוך ביתו כי חותני הרב הגאון ז"ל למד תורה"ק לשמה והי' מגזע היחוס מנכדי רש"ל ז"ל ומגזע בעל הלבושים ולמעלה בקודש ונהג את עדתו בעיר מאגרוב יותר מעשרים שנים ואח"כ נתקבל לעיר איזיראן בשנת תרנ"ד והי' בשם עד יום פטירתו כ"ג אלול תרנ"ט וחידש בשם הרבה חידושים ויש ממנו לאלפים קונטרסים אשר יגע לעת זקנתו חבל על דאבדין בעת רעש המלחמה למאות קונטרסים והנני חותם בכל הברכות ובברכה המושלשת בתוה"ק יברכך וכו' יאר וכו' ישא וכו' עד שלום דברי המצפה לישועת כלל ישראל לטובה ולברכה בב"א והמברכם בכל טוב.

הק' מאיר רוקח מקאזלוב חופ"ק מארניפאל.

Figure 5: Preface, by Mayer Rokach Tarnopol, to Ginzei Yosef by Yosef Alter Epstein (N.D.'s great-great-grandfather). The second line of the image says "3rd day of [the weekly reading of] Terumah [5]692", which is February 9, 1932. The reading Terumah and the year are also given by a quotation from Terumah, "MNRT zhB thor" in which the large letters indicate the year, [5]692.

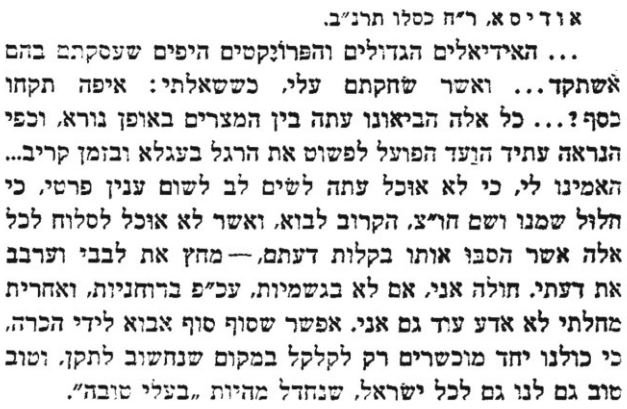

אודיסא, ר"ח כסלו תרנ"ב.
... האידיאלים הגדולים והפרוזקטים היפים שעסקתם בהם
אשתקד... ואשר שחקתם עלי, כששאלתי: איפה תקחו
כסף?... כל אלה הביאונו עתה בין המצרים באופן נורא, וכפי
הנראה עתיד הנַעַד הפועל לפשוט את הרגל בעגלא ובזמן קריב...
האמינו לי, כי לא אוכל עתה לשים לב לשום ענין פרטי, כי
חלול שמנו ושם חו"צ, הקרוב לבוא, ואשר לא אוכל לסלוח לכל
אלה אשר הסבו אותו בקלות דעתם, — מחץ את לבבי ופרבב
את דעתי. חולה אני, אם לא בגשמיות, עכ"פ ברוחניות, ואחרית
מחלתי לא אדע עוד גם אני. אפשר שסוף סוף אבוא לידי הכרה,
כי כולנו יחד מוכשרים רק לקלקל במקום שנחשוב לתקן, וטוב
טוב גם לנו גם לכל ישראל, שנחדל מהיות „בעלי טובה".

Figure 6: An ambiguous date in the writings of Ahad ha-Am (Asher Zvi Hirsch Ginsberg, 1856–1927). The date reads "Odessa, New month of Kislev 652". The 5 (thousand) has been omitted, so this is 5652 AM but the problem is that the "new month" of that Kislev was two days long. Presumably the second day is meant (December 2, 1891), which is the first of Kislev, rather than the last of Marheshvan.

IV. The Islamic Calendar

The Islamic calendar is a strictly lunar calendar, with no intercalation of months. Its independence of the solar cycle means that its months do not occur in fixed seasons, but migrate through the solar year. As on the Hebrew calendar, days begin at sunset. Virtually all Moslems follow an observation-based calendar computed, by the majority of the Moslem world, starting at sunset of Thursday, July 15, 622 CE (Julian); days begin at sunset and new months begin when witnesses sight the new lunar crescent, so computations are inevitably just (close) approximations to actual practice.

Islamic astronomers developed an arithmetic approximation that is used for estimation. In it, there are twelve months, which contain, alternately, 30 or 29 days. The twelfth month contains 29 days in an ordinary year and 30 days in a leap year, with 11 out every 30 years comprising 355 days, rather than 354.

V. The Persian Calendar

The modern Persian calendar, adopted in Iran in 1925, is a solar calendar designed in the eleventh century. The year begins on the day when the vernal equinox (approximately March 20) occurs before true noon (midday) and is postponed to the next day if the equinox is on or after true noon. Days begin at local zone midnight. The week begins on Saturday; as in the Hebrew and Islamic calendars, the days of the week are numbered, not named.

VI. Pitfalls to Avoid

Early releases of the original spreadsheet program Lotus 1-2-3® treated 2000 as a nonleap year—a problem eventually fixed. However, all releases of Lotus 1-2-3® took 1900 as a leap year, which is a serious problem with historical data. Excel®, part of Microsoft Office®, suffers from the same flaw.

Days on the Hebrew calendar begin at sunset, but secular days begin at midnight. Thus determining the proper date for births and deaths requires knowing both the time of day (and local method of time measurement), as well as the specific location of the event; without such details, one can only approximate the correct date to within one day.

One common misconception regarding the Hebrew calendar is that the correspondence with the Gregorian calendar repeats every 19 years. For example, the Diaspora Museum's website a few years ago stated the following:

> *Open the Index volume of the* Encyclopaedia Judaica*, page 109, to find converting tables of Hebrew and Gregorian dates for the years 1920 through 2020. If you look for a year beyond the period covered by those tables, do not worry. Hebrew dates coincide with Gregorian dates every 19 years. For instance: do you want to know which Gregorian date corresponds with Tishrei 12 of the year 1900? Look what was the Gregorian date for Tishrei 12 in 1938 (19 × 2) or any other multiple of 19 and you will discover.*

This, however, is usually not the case because of the irregular Gregorian leap year rule and the irregular applicability of the delays. In fact, Tishrei 12 in 1938 fell on October 7, while in 1900 it was on October 5! Nor does the Hebrew calendar repeat its pattern every 247 years (the so called "Calendar Round of Nahshon Gaon"). In the 17th century, Hezekiah ben David da Silva of Jerusalem complained about such published tables for the Hebrew calendar:

> *I have seen disaster and scandal [on the part] of some intercalators who are of the opinion that the character [of years] repeats every thirteen cycles. For the sake of God, do not rely and do not lean on them. "Far be it from thee to do after this manner," which will — perish the thought— cause the holy and awesome fast to be nullified, leaven to be eaten on Passover, and the holidays to be desecrated. Therefore, you the reader, "Hearken now unto my voice, I will give thee counsel, and God be with thee." Be cautious and careful lest you forget. . . what I am writing regarding this matter, since it is done according to exact arithmetic, "divided well," and is precise on all counts. . . from the 278th cycle [1521 CE] until the end of time.*

"Anyone who separates from it, it is as if he separates [himself] from life [itself]."

By the "character" of a year, da Silva means the day of the week of New Year and the length of the year. In fact, the Hebrew calendar repeats only after 689,472 years, as was pointed out by the celebrated Persian Moslem writer, al-Biruni, in 1000 CE.

Most Asian calendars are lunisolar, like the Hebrew calendar, and do not repeat every 19 years, though they are often said to. Deciphering a date on one of these can be quite difficult: calendarists may use different conventions for their calculations; the day of the month can vary from location to location, as they may be based on the phase of the moon at local sunrise, for example; any month of the year can be leap, and some months may even be expunged, again with variations between calendar systems and locations; the months have different names and sequences in different regions; new year may differ from calendar to calendar; and many eras are used for the year number, some beginning from year 0 and others from 1. (We recently helped determine the possible Gregorian dates corresponding to a Buddhist lunisolar date on a relatively recent birth certificate from a Mon village in Burma.)

The dates of Jewish holidays are frequently given erroneously. For example, the United States Naval Observatory's web site had (until they were informed) incorrect dates for Passover in the years 2028 and 2029 (April 9 and March 29, instead of April 11 and March 31, respectively). Other examples are shown in Figures 7 and 8.

The correct use of the well-known formula by Gauss (see his *Werke, Herausgegeben von der Königlichen Gesellschaft der Wissenschaften*, Göttingen, vol. 6, pp. 80–81, 1874 CE) for the date of the first day of Passover requires high precision calculations, making it difficult to use correctly.

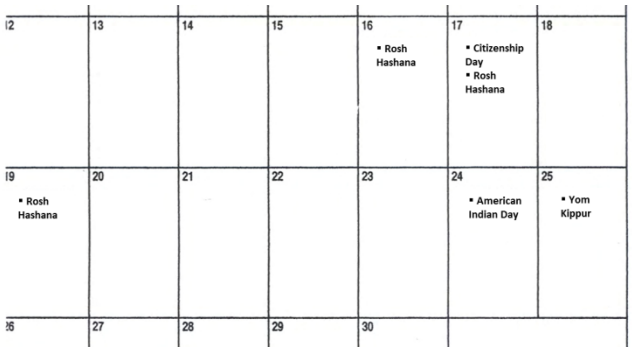


Figure 7: Delrina Technology's 1993 Daily Planner had three days for Rosh ha-Shanah.

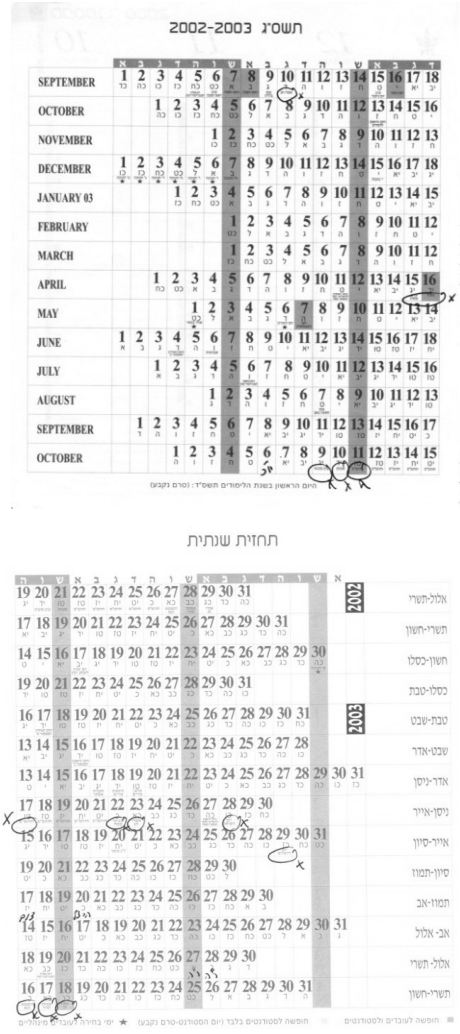


Figure 8: Tel Aviv University calendar for 2002–3 with a plethora of errors.

VII. Resources

Books

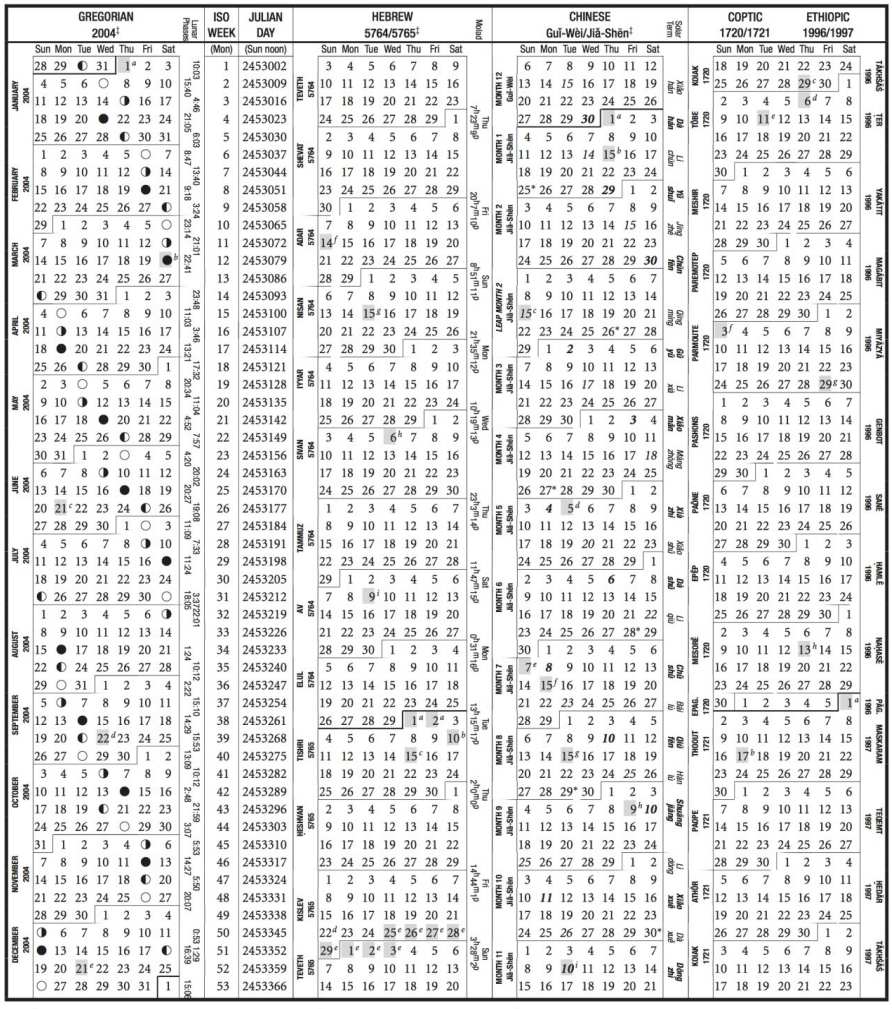
The most comprehensive and easily available modern reference book is *Calendrical Tabulations, 1900–2200*, Edward M. Reingold and Nachum Dershowitz, Cambridge: Cambridge University Press, 2002. This book (see Figures 9–10) gives a set of fully accurate, easy-to-use tables that simultaneously display the date on different calendars over a 300-year period. Included are the Gregorian, Julian, Hebrew, Chinese, Coptic, Ethiopic, Persian, Hindu lunar, Hindu solar, and Islamic calendars, as well as the phases of the moon, dates of solstices

and equinoxes, and religious and other special holidays for all the calendars shown.

The dates given in *Calendrical Tabulations* are based on algorithms from the second (2001) edition of *Calendrical Calculations*, Nachum Dershowitz and Edward M. Reingold Cambridge: Cambridge University Press, 3rd rev. ed., 2008, which gives precise algorithmic (very technical) treatments of most of the major calendars of the world, as well as a great deal of historical material.

A standard, reliable work for converting dates between the Gregorian and Hebrew calendars is *The Comprehensive Hebrew Calendar: Its Structure, History and One Hundred Years of Corresponding Dates 5660–5760, 1900–2000*, Arthur Spier, New York: Behrman House, 1952 (4th revised ed., *The Comprehensive Hebrew Calendar: Twentieth to Twenty-Second Century*, 5660-5860, 1900-2100, with preface and extended tables by H. Mandelbaum, New York: Feldheim Publishers, 1986), which has tables for the 20th and 21st centuries (in some later editions). Sabbath Torah readings and holidays are noted. The book includes detailed rules (corrected in the third edition) for determining Hebrew birthdays and for yahrzeit according to prevalent Ashkenazic practice. (See Figures 11–12.)

2004



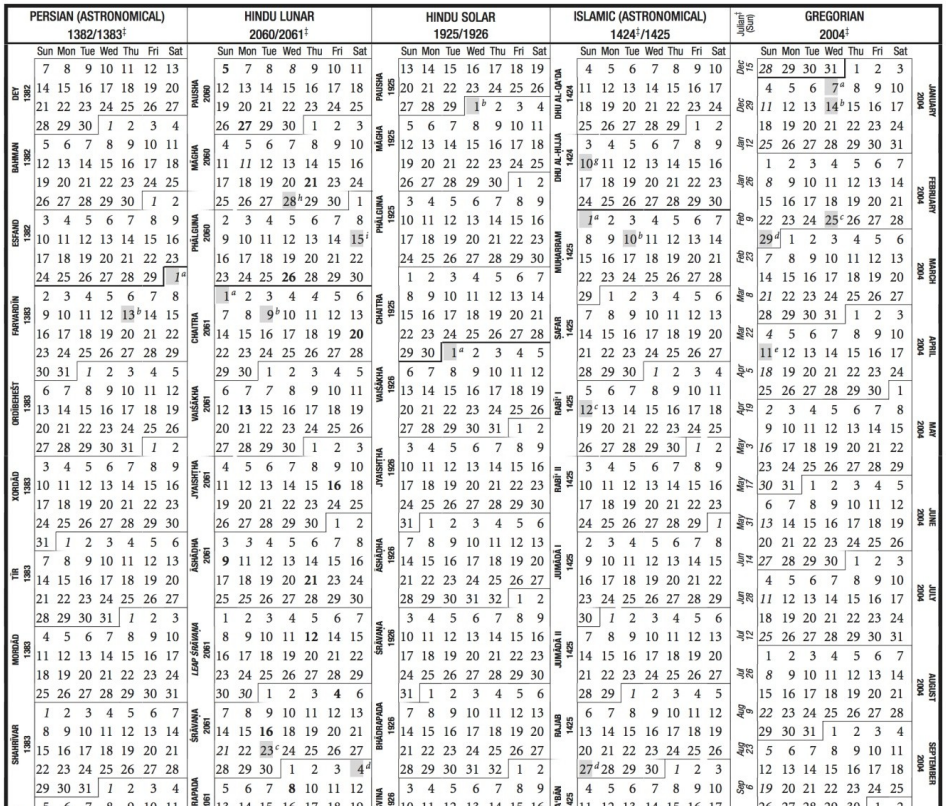
‡Leap year
[a]New Year
[b]Spring (6:48)
[c]Summer (0:57)
[d]Autumn (16:30)
[e]Winter (12:41)
● New moon
◐ First quarter moon
○ Full moon
◑ Last quarter moon

‡Leap year
[a]New Year
[b]Yom Kippur
[c]Sukkot
[d]Winter starts
[e]Ḥanukkah
[f]Purim
[g]Passover
[h]Shavuot
[i]Fast of Av

‡Leap year
[a]New Year (4702, Monkey)
[b]Lantern Festival
[c]Qīngmíng
[d]Dragon Festival
[e]Qiqiǎo
[f]Hungry Ghosts
[g]Mid-Autumn Festival
[h]Double-Ninth Festival
[i]Dōngzhì
*Start of 60-name cycle

[a]New Year
[b]Building of the Cross
[c]Christmas
[d]Jesus's Circumcision
[e]Epiphany
[f]Easter
[g]Mary's Announcement
[h]Jesus's Transfiguration

Figure 9: Verso page from Reingold and Dershowitz's *Calendrical Tabulations*.



‡Leap year
[a]New Year
[b]Sizdeh Bedar

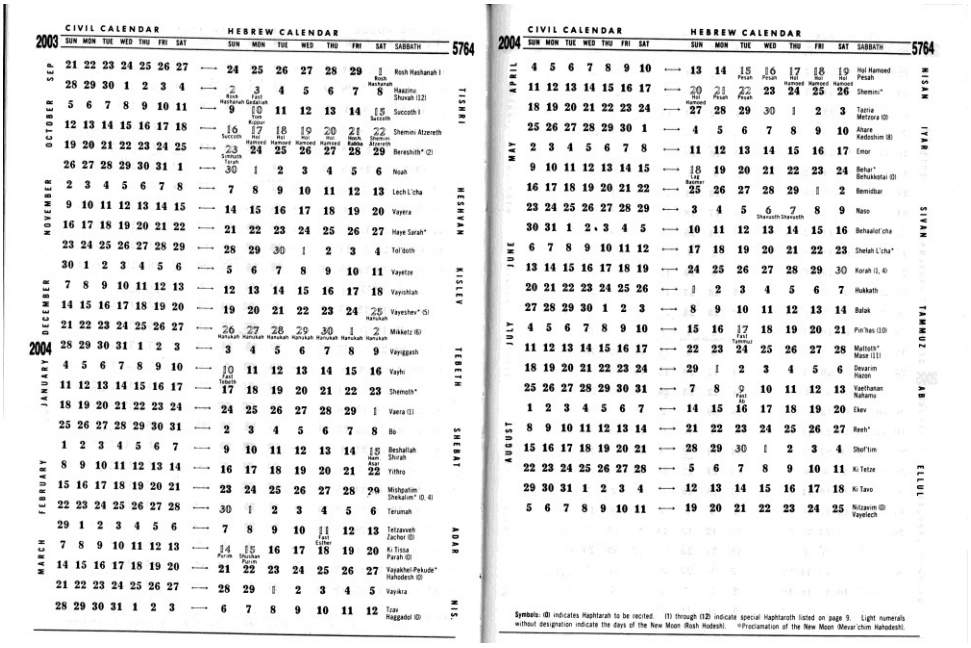
‡Leap year
[a]New Year (Tāraṇa)
[b]Birthday of Rāma
[c]Birthday of Krishna
[d]Ganēśa Chaturthī
[e]Dashara
[f]Diwali
[g]Birthday of Vishnu
[h]Night of Śiva
[i]Holi

[a]New Year (Hemalamba)
[b]Pongal

‡Leap year
[a]New Year
[b]'Ashūrā'
[c]Prophet's Birthday
[d]Ascent of the Prophet
[e]Start of Ramaḍān
[f]'Id al-Fiṭr
[g]'Id al-'Aḍḥā

‡Leap year
[a]Orthodox Christmas
[b]Julian New Year
[c]Ash Wednesday
[d]Feast of Orthodoxy
[e]Easter (also Orthodox)
[f]Advent
[h]Christmas

Figure 10: Recto page from Reingold and Dershowitz's *Calendrical Tabulations*.



2003	CIVIL CALENDAR SUN	MON	TUE	WED	THU	FRI	SAT		HEBREW CALENDAR SUN	MON	TUE	WED	THU	FRI	SAT	SABBATH	5764
SEP	21	22	23	24	25	26	27	⟷	24	25	26	27	28	29	I Rosh Hashanah	Rosh Hashanah I	TISHRI
	28	29	30	1	2	3	4	⟷	2 Rosh Hashanah	3 Fast Gedaliah	4	5	6	7	8	Haazinu Shuvah (12)	
OCTOBER	5	6	7	8	9	10	11	⟷	9	10 Yom Kippur	11	12	13	14	15 Sukkoth	Succoth I	
	12	13	14	15	16	17	18	⟷	16 Sukkoth	17 Hol Hamoed	18 Hol Hamoed	19 Hol Hamoed	20 Hol Hamoed	21 Hosh. Hoshana	22 Shemini Atzereth	Shemini Atzereth	
	19	20	21	22	23	24	25	⟷	23 Simhath Torah	24	25	26	27	28	29	Bereshith* (2)	
	26	27	28	29	30	31	1	⟷	30	I	2	3	4	5	6	Noah	
NOVEMBER	2	3	4	5	6	7	8	⟷	7	8	9	10	11	12	13	Lech L'cha	HESHVAN
	9	10	11	12	13	14	15	⟷	14	15	16	17	18	19	20	Vayera	
	16	17	18	19	20	21	22	⟷	21	22	23	24	25	26	27	Haye Sarah*	
	23	24	25	26	27	28	29	⟷	28	29	30	I	2	3	4	Tol'doth	
	30	1	2	3	4	5	6	⟷	5	6	7	8	9	10	11	Vayetze	KISLEV
DECEMBER	7	8	9	10	11	12	13	⟷	12	13	14	15	16	17	18	Vayishlah	
	14	15	16	17	18	19	20	⟷	19	20	21	22	23	24	25 Hanukah	Vayeshev* (5)	
	21	22	23	24	25	26	27	⟷	26 Hanukah	27 Hanukah	28 Hanukah	29 Hanukah	30 Hanukah	1 Hanukah	2 Hanukah	Mikketz (6)	
2004	28	29	30	31	1	2	3	⟷	3	4	5	6	7	8	9	Vayiggash	TEBETH
JANUARY	4	5	6	7	8	9	10	⟷	10 Fast Tebeth	11	12	13	14	15	16	Vayhi	
	11	12	13	14	15	16	17	⟷	17	18	19	20	21	22	23	Shemoth*	
	18	19	20	21	22	23	24	⟷	24	25	26	27	28	29	I	Vaera (1)	SHEBAT
	25	26	27	28	29	30	31	⟷	2	3	4	5	6	7	8	Bo	
	1	2	3	4	5	6	7	⟷	9	10	11	12	13	14	15 Hamishah Asar	Beshallah Shirah	
	8	9	10	11	12	13	14	⟷	16	17	18	19	20	21	22	Yithro	
	15	16	17	18	19	20	21	⟷	23	24	25	26	27	28	29	Mishpatim Shekalim* (0, 4)	
FEBRUARY	22	23	24	25	26	27	28	⟷	30	I	2	3	4	5	6	Terumah	
	29	1	2	3	4	5	6	⟷	7	8	9	10	11 Fast Esther	12	13	Tetzaveh Zachor (0)	ADAR
	7	8	9	10	11	12	13	⟷	14 Purim	15 Shushan Purim	16	17	18	19	20	Ki Tissa Parah (0)	
	14	15	16	17	18	19	20	⟷	21	22	23	24	25	26	27	Vayakhel-Pekude* Hahodesh (0)	
	21	22	23	24	25	26	27	⟷	28	29	I	2	3	4	5	Vayikra	NISAN
	28	29	30	31	1	2	3	⟷	6	7	8	9	10	11	12	Tzav Haggadol (0)	

2004	CIVIL CALENDAR SUN	MON	TUE	WED	THU	FRI	SAT		HEBREW CALENDAR SUN	MON	TUE	WED	THU	FRI	SAT	SABBATH	5764
APRIL	4	5	6	7	8	9	10	⟷	13	14	15 Pesah	16 Pesah	17 Hol Hamoed	18 Hol Hamoed	19 Hol Hamoed	Hol Hamoed Pesah	NISAN
	11	12	13	14	15	16	17	⟷	20 Hol Hamoed	21 Pesah	22 Pesah	23	24	25	26	Shemini*	
	18	19	20	21	22	23	24	⟷	27	28	29	30	1	2	3	Tazria Metzora (0)	IYAR
	25	26	27	28	29	30	1	⟷	4	5	6	7	8	9	10	Ahare Kedoshim (8)	
MAY	2	3	4	5	6	7	8	⟷	11	12	13	14	15	16	17	Emor	
	9	10	11	12	13	14	15	⟷	18 Lag Baomer	19	20	21	22	23	24	Behar* Behukkotai (0)	SIVAN
	16	17	18	19	20	21	22	⟷	25	26	27	28	29	I	2	Bemidbar	
	23	24	25	26	27	28	29	⟷	3	4	5	6 Shavuoth	7 Shavuoth	8	9	Naso	
	30	31	1	2	3	4	5	⟷	10	11	12	13	14	15	16	Behaalot'cha	TAMMUZ
JUNE	6	7	8	9	10	11	12	⟷	17	18	19	20	21	22	23	Shelah L'cha*	
	13	14	15	16	17	18	19	⟷	24	25	26	27	28	29	30	Korah (1, 4)	
	20	21	22	23	24	25	26	⟷	I	2	3	4	5	6	7	Hukkath	AB
	27	28	29	30	1	2	3	⟷	8	9	10	11	12	13	14	Balak	
JULY	4	5	6	7	8	9	10	⟷	15	16	17 Fast Tammuz	18	19	20	21	Pin'has (10)	
	11	12	13	14	15	16	17	⟷	22	23	24	25	26	27	28	Mattoth* Mase (11)	
	18	19	20	21	22	23	24	⟷	29	I	2	3	4	5	6	Devarim Hazon	
	25	26	27	28	29	30	31	⟷	7	8	9 Fast Ab	10	11	12	13	Vaethanan Nahamu	ELUL
AUGUST	1	2	3	4	5	6	7	⟷	14	15	16	17	18	19	20	Ekev	
	8	9	10	11	12	13	14	⟷	21	22	23	24	25	26	27	Reeh*	
	15	16	17	18	19	20	21	⟷	28	29	30	I	2	3	4	Shof'tim	
	22	23	24	25	26	27	28	⟷	5	6	7	8	9	10	11	Ki Tetze	
	29	30	31	1	2	3	4	⟷	12	13	14	15	16	17	18	Ki Tavo	
	5	6	7	8	9	10	11	⟷	19	20	21	22	23	24	25	Nitzavim (0) Vayelech	

Symbols: (0) indicates Haphtarah to be recited. (1) through (12) indicate special Haphtaroth listed on page 9. Light numerals without designation indicate the days of the New Moon (Rosh Hodesh). *Proclamation of the New Moon (Mevarchim Hahodesh).

Figure 11: A page from Spier's *The Comprehensive Hebrew Calendar*.

JULY	27	28	29	30	1	2	3	⟷	8	9	10	11	12	13	14	Balak
	4	5	6	7	8	9	10	⟷	15	16	17 Fast Tammuz	18	19	20	21	Pin'has (10)
	11	12	13	14	15	16	17	⟷	22	23	24	25	26	27	28	Mattoth* Mase (11)
	18	19	20	21	22	23	24	⟷	29	I	2	3	4	5	6	Devarim Hazon
	25	26	27	28	29	30	31	⟷	7	8	9 Fast Ab	10	11	12	13	Vaethanan Nahamu
	1	2	3	4	5	6	7	⟷	14	15	16	17	18	19	20	Ekev

TAMMUZ AB

Figure 12: Spier detail.

The index volume of *Encyclopaedia Judaica*, Cecil Roth, ed., New York: Macmillan, 1971 contains a somewhat awkward calendar for the years 1920–2020, arranged by Gregorian year. The corresponding Hebrew date is given for each Gregorian day. Dates of all holidays and fasts (and an indication of postponement, if any), as well as the Sabbath readings for the Diaspora, are included.

The most highly-regarded scholarly tables are those in *Kalendariographische und chronologische Tafeln*, Robert G. Schram, J. C. Hinrichs'sche Buchhandlung, Leipzig, 1908. It covers all calendars of significance for dates from thousands of years ago until 2000. (See Figure 13.) However, this volume is rare, awkward to use, and requires some knowledge of German.

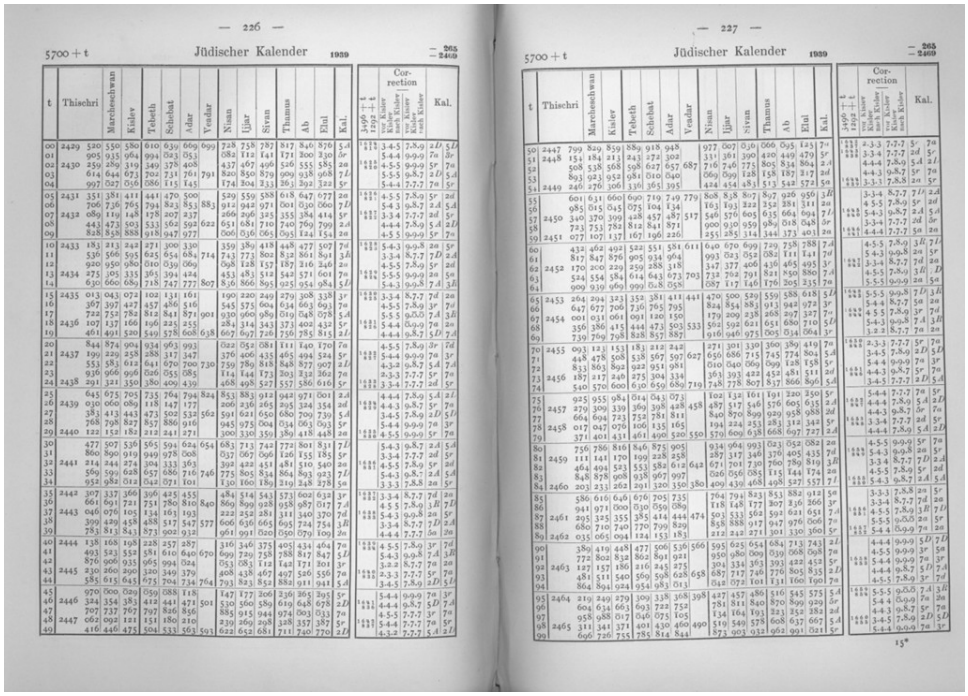


Figure 13: Facing pages from the Jewish calendar section of Schram's *Kalendariographische und chronologische Tafeln*.

For the Islamic and Persian calendars, *Wüstenfeld-Mahler'sche Vergleichungs-Tabellen zur muslimischen und iranischen Zeitrechung mit Tafeln zur Umrechnung orient-christlicher Ären,* F. Wüstenfeld and E. Mahler, 3rd ed. revised by J. Mayr and B. Spuler, Deutsche Morgenländische Gesellschaft, Wiesbaden, 1961, is an excellent, though rare, reference. See Figure 14.

The most ubiquitous set of calendar tables, *The Book of Calendars*, F. Parise, ed., Facts on File, New York, 1982 (see Figure 15), is so filled with errors as to be useless. Avoid it!

Determining the time of sunset (needed for ascertaining precise Hebrew dates) can be daunting. The most useful reference in this context is *Halachic Times for Home and Travel. World-Wide Times-of-Day Tables with Halachic and Scientific Foundations and Permanent Calendar*, Leo Levi, Rubin Mass, Ltd., Jerusalem, 1992; expanded 3rd ed., 2000. This book gives tables for each degree of latitude and for 73 cities with large Jewish populations. Unlike most published tables, which use mean values for dawn regardless of season or location, the times in this work are derived from astronomical calculations of the depression angle of the sun. The English section of the book also includes a short chapter on the calendar and tables that allow conversion between Gregorian and Hebrew dates. It should be noted that there remain disputes as to where to place the

dateline for the religious purposes and what times to use in polar regions. In practice, the International Dateline is used and the times of prayer and observance at nearby synagogues below the Arctic Circle are followed.

Hijra-Jahr	Muharram 30 Tage	Şafar 29 Tage	Rabi' I. 30 Tage	Rabi' II. 29 Tage	Gumâdâ I. 30 Tage	Gumâdâ II. 29 Tage	Rağab 30 Tage	Ša'bân 29 Tage	Ramaḍân 30 Tage	Šawwâl 29 Tage	Dû-l-qa'da 30 Tage	Dû-l-higga 29—30 Tage
1416	1995 V 31 D	VI 30 F	VII 29 G	VIII 28 B	IX 26 C	X 26 E	XI 24 F	XII 24 A	1996 I 22 B	II 21 D	III 21 E	IV 20 G
1417	1996 V 19 A	VI 18 C	VII 17 D	VIII 16 F	IX 14 G	X 14 B	XI 12 C	XII 12 E	1997 I 10 F	II 9 A	III 10 B	IV 9 D
1418	1997 V 9 F	VI 8 A	VII 7 B	VIII 6 D	IX 4 E	X 4 G	XI 2 A	XII 2 C	XII 31 D	1998 I 30 F	II 28 G	III 30 B
1419	1998 IV 28 C	V 28 E	VI 26 F	VII 26 A	VIII 24 B	IX 23 D	X 22 E	XI 21 G	XII 20 A	1999 I 19 C	II 17 D	III 19 F
1420	1999 IV 17 G	V 17 B	VI 15 C	VII 15 E	VIII 13 F	IX 12 A	X 11 B	XI 10 D	XII 9 E	2000 I 8 G	II 6 A	III 7 C
1421	2000 IV 6 E	V 6 G	VI 4 A	VII 4 C	VIII 2 D	IX 1 F	IX 30 G	X 30 B	XI 28 C	XII 28 E	2001 I 26 F	II 25 A
1422	2001 III 26 B	IV 25 D	V 24 E	VI 23 G	VII 22 A	VIII 21 C	IX 19 D	X 19 F	XI 17 G	XII 17 B	2002 I 15 C	II 14 E
1423	2002 III 15 F	IV 14 A	V 13 B	VI 12 D	VII 11 E	VIII 10 G	IX 8 A	X 8 C	XI 6 D	XII 6 F	2003 I 4 G	II 3 B
1424	2003 III 5 D	IV 4 F	V 3 G	VI 2 B	VII 1 C	VII 31 E	VIII 29 F	IX 28 A	X 27 B	XI 26 D	XII 25 E	2004 I 24 G
1425	2004 II 22 A	III 23 C	IV 21 D	V 21 F	VI 19 G	VII 19 B	VIII 17 C	IX 16 E	X 15 F	XI 14 A	XII 13 B	2005 I 12 D
1426	2005 II 10 E	III 12 G	IV 10 A	V 10 C	VI 8 D	VII 8 F	VIII 6 G	IX 5 B	X 4 C	XI 3 E	XII 2 F	2006 I 1 A
1427	2006 I 31 C	II 2 E	III 31 F	IV 30 A	V 29 B	VI 28 D	VII 27 E	VIII 26 G	IX 24 A	X 24 C	XI 22 D	XII 22 F
1428	2007 I 20 G	II 19 B	III 20 C	IV 19 E	V 18 F	VI 17 A	VII 16 B	VIII 15 D	IX 13 E	X 13 G	XI 11 A	XII 11 C
1429	2008 I 10 E	II 9 G	III 9 A	IV 8 C	V 7 D	VI 6 F	VII 5 G	VIII 4 B	IX 2 C	X 2 E	XI 31 F	XII 30 A
1430	2008 XII 29 B	2009 I 28 D	II 26 E	III 28 G	IV 26 A	V 26 C	VI 24 D	VII 24 F	VIII 22 G	IX 21 B	X 20 C	XI 19 E

Figure 14: Detail from Wüstenfeld and Mahler's Islamic/Persian tables.

19 Year Cycle No.	Hebrew Year	Calendar Number	Days in Year	Day of Week	Western Year	Commencement 1st of Tishri (Gregorian)		19 Year Cycle No.	Hebrew Year	Calendar Number	Days in Year	Day of Week	Western Year	Commencement 1st of Tishri (Gregorian)	
	5713	6	355	Sa	1952*	20	Sep		5747	6	355	Sa	1986	4	Oct
	5714	12	383	Th	1953	10	Sep		5748	5	354	Th	1987	24	Sep
	5715	3	354	Tu	1954	28	Sep		5749	9	383	Mo	1988*	12	Sep
	5716	6	355	Sa	1955	17	Sep		5750	6	355	Sa	1989	30	Sep
	5717	11	385	Th	1956*	6	Sep		5751	5	354	Th	1990	20	Sep
	5718	5	354	Th	1957	26	Sep		5752	8	385	Mo	1991	9	Sep
	5719	9	383	Mo	1958	15	Sep		5753	2	353	Mo	1992*	28	Sep
									5754	4	355	Th	1993	16	Sep
302	5720	6	355	Sa	1959	3	Oct		5755	10	384	Tu	1994	6	Sep
	5721	5	354	Th	1960*	22	Sep		5756	1	355	Mo	1995	25	Sep
	5722	9	383	Mo	1961	11	Sep		5757	14	383	Sa	1996*	14	Sep
	5723	6	355	Sa	1962	29	Sep								
	5724	5	354	Th	1963	19	Sep	304	5758	5	354	Th	1997	2	Oct
	5725	8	385	Mo	1964*	7	Sep		5759	1	355	Mo	1998	21	Sep
	5726	2	353	Mo	1965	27	Sep		5760	13	385	Sa	1999	11	Sep
	5727	11	385	Th	1966	15	Sep		5761	7	353	Sa	2000*	30	Sep
	5728	5	354	Th	1967	5	Oct		5762	3	354	Tu	2001	18	Sep
	5729	1	355	Mo	1968*	23	Sep		5763	13	385	Sa	2002	7	Sep
	5730	14	383	Sa	1969	13	Sep		5764	6	355	Sa	2003	27	Sep
	5731	5	354	Th	1970	1	Oct		5765	12	383	Th	2004*	16	Sep
	5732	1	355	Mo	1971	20	Sep		5766	3	354	Tu	2005	4	Oct
	5733	14	383	Sa	1972*	9	Sep		5767	6	355	Sa	2006	23	Sep
	5734	4	355	Th	1973	27	Sep		5768	12	383	Th	2007	13	Sep
	5735	1	355	Mo	1974	17	Sep		5769	3	354	Tu	2008*	30	Sep
	5736	13	385	Sa	1975	6	Sep		5770	6	355	Sa	2009	19	Sep
	5737	7	353	Sa	1976*	25	Sep		5771	11	385	Th	2010	9	Sep
	5738	10	384	Tu	1977	13	Sep		5772	5	354	Th	2011	29	Sep
									5773	2	353	Mo	2012*	17	Sep
303	5739	1	355	Mo	1978	2	Oct		5774	11	385	Th	2013	5	Sep
	5740	6	355	Sa	1979	22	Sep		5775	5	354	Th	2014	25	Sep
	5741	12	383	Th	1980*	11	Sep		5776	8	385	Mo	2015	14	Sep
	5742	3	354	Tu	1981	29	Sep								
	5743	6	355	Sa	1982	18	Sep	305	5777	2	353	Mo	2016*	3	Oct
	5744	11	385	Th	1983	8	Sep		5778	5	354	Th	2017	21	Sep
	5745	5	354	Th	1984*	27	Sep		5779	8	385	Mo	2018	10	Sep
	5746	9	383	Mo	1985	16	Sep		5780	1	355	Mo	2019	30	Sep

Figure 15: A page from Parise. These tables are laden with errors.

Interpreting recorded times of day also requires knowing details of local time-zone practice. The best source for historical time zones is the pair of books: *The American Atlas: U.S. Longitudes & Latitudes Time Changes and Time Zones*, 5th ed., Thomas G. Shanks, ACS Publications, San Diego, CA, 1996; *The International Atlas: World Longitudes & Latitudes Time Changes and Time Zones*, 5th ed., Thomas G. Shanks, ACS Publications, San Diego, CA, 1999. These books contain extensive longitude and latitude values for locations throughout the world (needed for sunset calculations).

For dates of changeover from the Julian to the Gregorian calendar, see *Explanatory Supplement to the Astronomical Ephemeris and the American Ephemeris and Nautical Almanac*, Her Majesty's Stationery Office, London, 1961.

Software

There are numerous programs available over the Internet for date conversion. The most extensive and accurate is Calendrica, http://www.calendarists.com. This software package is based on the algorithms of Calendrical Calculations. An applet for easy conversion among more than two dozen calendars is available online.

A excellent PC-based Hebrew calendar software was Joe Kohn's *Hebrew Calendar* for Windows; it is now called *Jewish Time* and distributed by Torah Educational Software, http://jewishsoftware.com. It includes a full Hebrew/Gregorian calendar (for 1600–2200), all Jewish holidays, and extensive time-of-day calculations for dawn, sunrise, sunset, candle lighting, dusk, and so on. Another program is Danny Sadinoff's Hebcal, for either online use or for installing under Unix or Windows, available for free at http://www.hebcal.com. Software is also available for the Macintosh, such as the Jewish Calendar by Avi Drissman (http://www.drissman.com/avi/mac/JewishCalendar).

Cumberland Family Software's Universal Calendar Calculator for Windows (available on the Internet at no charge at http://sites.google.com/site/cftwin) performs conversions between a large selection of calendars. It also contains dates of United States, Christian (Nicæan Rule and Modern), Islamic, Jewish, and Chinese holidays and is part of their genealogical software package.

BIOGRAPHIES

Beyond his expertise in calendars, Nachum Dershowitz is a leading figure in software verification in general and termination of programs in particular; he is an international authority on equational inference and term rewriting. Other areas in which he has made major contributions include program semantics and combinatorial enumeration. Dershowitz has authored or coauthored more than 100 research papers and several books and has held visiting positions at prominent institutions around the globe. He has won numerous awards for his research and teaching. He was born in 1951, and his graduate degrees in applied mathematics are from the Weizmann Institute in Israel. He is currently a professor of computer science at Tel Aviv University and incumbent of their chair in computational logic.

Edward M. Reingold was born in Chicago, Illinois, in 1945. He has an undergraduate degree in mathematics from the Illinois Institute of Technology and a doctorate in computer science from Cornell University. Reingold was a faculty member in the Department of Computer Science at the University of Illinois at Urbana-Champaign from 1970-2000; he retired as a Professor Emeritus of Computer Science in December 2000 and moved to the Department of Computer Science at the Illinois Institute of Technology as professor and chair, an administrative post he held until 2006. His research interests are in theoretical computer science -especially the design and analysis of algorithms and data structures. A Fellow of the Association for Computing Machinery since 1995, Reingold has authored or coauthored more than 75 research papers and 10 books; his papers on backtrack search, generation of combinations, weight-balanced binary trees, and drawing of trees and graphs are considered classics. He has won awards for his undergraduate and graduate teaching. Reingold is intensely interested in calendars and their computer implementation; in addition to Calendrical Calculations and Calendrical Tabulations, he is the author and former maintainer of the calendar/diary part of GNU Emacs.