

## The calendars of ancient Egypt

The Egyptians of the ancient world used no fewer than three calendars between the time of their earliest history around 3000BCE and the time of their conquest under the Persians in 525BCE.

The oldest of the three is an ecclesiological calendar that was used for setting dates and times for sacrifices, festivals and holidays. This was an empirical lunar calendar, but it also recognized the seasonal events that heralded the annual flooding of the Nile valley which were vital for agricultural practices in that region of the world.

In this calendar, the beginning of the year was marked by the heliacal rising of Sopdet (Sirius), which in the era from 3000BCE to 2500BCE occurred in late June (according to our calendar), just before the flooding began. (Recall that precession of the equinoxes causes the entire celestial sphere to shift over time, meaning that the heliacal rising of stars drifts slowly forward in time through the year; today, the heliacal rising of Sirius occurs in early August for observers in Egypt!) Between July and October, the Nile, flooded by rains that fell at the river's head in central Africa, would deposit rich sediments along the river valley. Here farmers could plant fruitful crops.

As the helical rising of a star is a solar event, this critical date for Egyptians provided a means to start the year. However, worship of lunar deities was of crucial importance in Egyptian culture, so the calendar was given a lunar foundation.

Consequently, the year began at sunrise on the day following observation of the first new Moon after the heliacal rising of Sirius. (Actually, a month began on the day following a night when the waning crescent of the previous Moon could no longer be seen; this does not necessarily correspond to the moment at which the Moon is new.)

The beginning of the year was also the beginning of the first of three seasons recognized by the Egyptians: **Akhet** (inundation), the season of Nile flooding (roughly between July and October in our calendar); **Peret** (going forth), the season for planting (roughly from October to March); and **Shomu** (deficiency), the season of the harvest, during which their stores and supply would slowly dwindle (roughly from March to July).

The year would normally contain 12 lunar months. At first these months were simply numbered within their appropriate season, four months per season: they were named First of Akhet, Second of Akhet, Third of Akhet, Fourth of Akhet, First of Peret, Second of Peret, etc. But eventually the months adopted unique names corresponding to an important festival or holiday that took place in that month (see Table 11.2, p. 154). In years that would contain a 13th new Moon, the additional month was intercalated at the end. Finally, we recall that each month contained three decades of ten days each. Days were numbered within each month, and years were numbered regnally.

As the Egyptians became more knowledgeable about the astronomical cycles for these events, they recognized that their months averaged 29.5 days long, so a 12-month year was  $12 \times 29.5 = 354$  days long. However, the heliacal rising of Sirius is a sidereal event that happens every 365 days. So the rising of Sirius would occur about 11 days later in the final month of every year. If the previous year, it occurred in the final 11 days of the year, then this year, it would skip the 12th month entirely; hence a 13th intercalary month would be needed whenever Sirius rose in the last 11 days of the final month of the present year.

The ecclesiological calendar was controlled by astronomer-priests, but the rest of the population felt the need for a much simpler calendar, independent of the need for careful astronomical observations and more amenable to civil business planning. So a second civil calculated calendar came into use in Egypt. This calendar consisted of 12 months of 30 days each, plus 5 additional **epagomenal** days [Gr. epagomene = intercalary, from epi + agein = inwards + to bring] to make a year of 365 days. These epagomenal days belonged to no month; they occurred at the end of the year and marked a series of special holidays, the birthdays of the gods Osiris, Horus, Set, Isis and Nephtys.

No sighting of Sirius was required to start this civil calendar and it ignored the sequence of phases of the Moon. So this calendar quickly went out of sync with astronomical events. Within a few months, the new Moon would no longer occur at the beginning of a month, and within a few years, the rising of Sirius would drift to later and later dates on this calendar. In fact, since the tropical year (as well as the sidereal year) is a quarter of a day longer than this 365-day civil year, the civil calendar came a full day earlier every four years with respect to the seasons. In the 1500 years of its use, it fell back an entire tropical year in length!

The Romans, who ruled Egypt between 32BCE and 395CE, called this civil calendar the *annus vagus* [L. wandering year], since it wandered freely against the seasons. Clearly, its simple structure was more compelling to the Egyptians than any disadvantages that might arise from untying it from astronomical events. It operated alongside the lunar ecclesiological calendar, which was still used for scheduling festivals and holidays.

A few world calendars still in use are based on this Egyptian civil calendar, adopting a different set of names for the months and epagomenal days, but having largely the same structure. These include the **Yazdegerd calendar** (used by Zoroastrians in regions of Iran, Azerbaijan and central Asia, and by Parsis in India) and the **Armenian calendar**.

Under the Ptolemies, from about the 4th c. BCE, a third calendar was invented to reconnect to the Moon's phases. It intercalated a 13th month into a civil year whenever the civil year started after the ecclesial year. This way, the new calendar would never go too far out of phase with the ecclesial calendar. (Unfortunately, this reformed calendar did not totally replace the earlier wandering civil calendar, and so all three calendars were simultaneously in use for centuries!)

Since the synodic month is, to four-place accuracy, 29.5306 days long and the *annus vagus* is always exactly 365 days long, this means that there will be

$$\frac{365 \text{ days / year}}{29.5306 \text{ days / month}} = 12.36 \text{ months / year}$$

But  $12.36 = \frac{1236}{100} = \frac{309}{25}$ , so there will be very nearly

309 synodic months every 25 civil years. In other words, the wandering of the civil calendar could be eliminated if, in the  $25 \times 12 = 300$  months that occur in every 25 civil years, we intercalate 9 additional months. This is exactly how the reformed calendar was engineered.

It did away with the epagomenal days entirely, and instead proposed a 25-year cycle of exactly 309 months: 16 of these years were **small years** of 12 months each, alternating 30 days and 29 days long, for a total of  $6 \times 30 + 6 \times 29 = 354$  days in each small year; and 9 of these years were **great years** of 13 months each, in which the 13th month was given 30 days, for a total of  $354 + 30 = 384$  days in a great year. This cycle was  $16 \times 354 + 9 \times 384 = 9120$  days long.

However,

$$\begin{aligned} 309 \text{ synodic months} &= 309 \times 29.5306 \text{ days} \\ &= 9124.9554 \text{ days} \end{aligned}$$

just an hour shorter than 9125 days. To keep in step with the moon, all that was needed was to intercalate 5 additional days into the full 25-year cycle. This was accomplished by adding a 30th day to the last 29-day month every 5th year.

In the 3rd c. BCE, Ptolemy III Euergetes (the third of the Ptolemies in the Alexandrian line of kings of Egypt), who was something of a scholar, attempted to introduce a new lunisolar calendar. He was aware of calculations of the length of the tropical year by Greek astronomers, and realized that

$$25 \text{ tropical years} = 25 \times 365.24 \text{ days} = 9131 \text{ days},$$

6 days longer than 25 lunar calendar years. So he proposed, in the Decree of Canopus in 239BCE, to intercalate an additional day at the end of every fourth year (as  $25 \div 6 \approx 4$ ).

His proposal was not adopted, however, until Roman times, when it was mandated in order to align the Egyptian calendar with the Roman Julian calendar, which was already using this intercalation method. The resulting calendar is now called the **Alexandrian calendar**; it survives today as the calendar in Ethiopia, and is also used by the Coptic church and other Christians in Ethiopia and Eritrea.

## The Babylonian calendar

The ancient Babylonian calendar, like the ones in Egypt, began as an empirical lunar calendar. Each year contained 12 months, with an occasional 13th intercalated to keep the lunar cycles in line with the seasonal year. Unlike in Egypt, however, the climate of Mesopotamia did not enjoy a flooding season. They recognized only two seasons, a *planting* season (roughly from December to May in our calendar) and a *harvesting* season (from June to November). Nonetheless, in certain places the calendar would have been divided into thirds, named simply *beginning of the year*, *middle of the year* and *end of the year*, containing four months each (the 13th month belonging to the end period).

Under the Akkadians (ca. 2000BCE), the year began with the **barley moon** (beginning in late May or early June), the start of the harvesting season. Months began on the evening of the sighting of the first crescent of the new Moon, the day starting at sunset. The decision to intercalate a 13th month was made by royal decree under the advisement of the king's priests, whenever it was deemed necessary. One cuneiform tablet from about 1000BCE claims that if the new Moon is found near the Pleiades at the start of the year, then there would be no need to intercalate a month that year.

Under the Babylonian kings of the middle of 8th c. BCE, the new year was shifted to the month that followed the spring equinox (named Nisanu – see Table 10.1, p. 148). In these later centuries, as the priests' understanding of astronomy improved, they recognized patterns in the cycle of years that required intercalating months. This 19-year **Metonic cycle**, named for the Greek astronomer Meton of Athens who described its function in the 5th c. BCE, called for a 13th month in the year numbers marked in bold below:

1, 2, **3**, 4, 5, **6**, 7, **8**, 9, 10, **11**,  
12, 13, 14, 15, 16, **17**, 18, **19**

In all of these years except the 17th, the intercalary month was added after the 12th month Adaru, and was named Adaru II. In the 17th year, which also happened to be the year of the cycle that started closest to the equinox, the intercalated month was slipped in after the 6th month Ululu, and was named Ululu II.

Babylonians were the first to use a 7-day week. However, their weeks were subdivisions of the month; they did not extend across one month to another as they do in our calendar. This may have begun as a way to mark the quarters of the Moon's phases ( $29.53 \text{ days} \div 4 = 7.3825 \approx 7 \text{ days}$ ).

Another non-astronomical explanation has been offered as well. Apparently, the Babylonians felt the number 7 to be quite *unlucky*. So they set aside the 7th, 14th, 21st and 28th day of every month as days of sacrifices to their major gods so as to ward off evil. In fact, the 19th day of the month, which would be reckoned as the 49th day of the previous 30-day month, was also observed as an especially unlucky “day of anger”, and it was dedicated to special sacrifices as well. This practice of a weekly holy day was then adopted by the Hebrews during their Babylonian exile in the 6th. c. BCE and would later be encoded in their religious law.

## The Jewish calendar

Our knowledge of the early history of the Hebrew calendar is sketchy. Before the time of King Solomon (10th c. BCE), there is evidence that they used an empirical lunisolar calendar in which the new year began at the first new Moon after the autumnal equinox. The day began at sunset, the month was announced by the high priest in Jerusalem on first sighting of the new crescent, and the decision to intercalate a 13th month depended on whether the barley harvest came in before the celebration of Passover in the spring, so that a proper offering of grain could be made to God on the day after the holiday.

During the time of the Babylonian captivity (586-537BCE), the Hebrews adopted the calendar of their captors, including the names of the 12 months:

1	Tishrei	30 days	7	Nisan	30 days
2	Cheshvan	29 days	8	Iyyar	29 days
3	Kislev	30 days	9	Sivan	30 days
4	Tevet	29 days	10	Tammuz	29 days
5	Shvat	30 days	11	Av	30 days
6	Adar	29 days	12	Elul	29 days

They also appropriated their 7-day week, with number-based names (see p. 397).

In 311BCE Seleucis Nicator took charge of the eastern part of the territory won by Alexander the Great and established an empire that stretched from present-day Turkey to Pakistan. This was the beginning of the Seleucid era, and the Jewish calendar counted years from this date until the 13th c. CE.

In 70 CE, Roman armies sacked Jerusalem and destroyed the Jewish Temple there. This event marks the **Great Diaspora** [Gr. dispersion], when Jews emigrated throughout the world. It then became most inconvenient for Jews to wait for news from Jerusalem about when the months – and their associated holidays and festivals – would begin. Some Jews in faraway lands like Spain adopted the practice of celebrating certain feasts on multiple consecutive days to make sure they would not be in violation of religious law! More and more of them simply worked out methods to determine the calendar by calculation.

One method for calculating the pattern of **common** 12-month years and **embolismic** 13-month years [Gr. embolismos = intercalation] was to notice that

$$8 \text{ tropical years} = 8 \times 365.25 \text{ days} = 2922 \text{ days}$$

whereas

$$99 \text{ lunations} = 99 \times 29.5306 \text{ days} \approx 2923.5 \text{ days.}$$

That is, 8 years is only a day-and-a-half shy of 99 synodic months. Since  $99 = 12 \times 8 + 3$ , a pattern of 3 embolismic years in every 8, according to the pattern

1, **2**, 3, 4, **5**, 6, 7, **8**,

would very nearly ensure an accurate calculated lunisolar calendar.

More common, however, than this 8-year cycle was the much more accurate 19-year Metonic cycle, which was widely adopted throughout the Diaspora. In some rabbinic traditions, it is reported that a calculated calendar of this type was established in Jerusalem in the 4th c. CE. It is certainly true that this calculated calendar was in use throughout the world by the 8th c. CE.

The day, which started at sunset (6 hours after noon), was divided into 24 hours according to the ancient Egyptian and Babylonian customs. Each hour was divided into 1080 parts called **halakim**:

$$\begin{aligned}
 1 \text{ halak} &= 1 \text{ hour} / 1080 \\
 &= 60 \text{ minutes} / 1080 \\
 &= 60 \times 60 \text{ seconds} / 1080 \\
 &= 3\frac{1}{3} \text{ seconds}
 \end{aligned}$$

The number 1080 seems to have been chosen because it is highly divisible. The synodic month, or **molod** in Hebrew, was determined to be exactly

$$1 \text{ molod} = 29 \text{ days, } 12 \text{ hours, } 793 \text{ halakim}$$

long; this converts to 29.5305941 days, impressive accuracy of less than half a second! Thus, it is possible to compare the length of a **common** year of 354 days ( $6 \times 30 + 6 \times 29 = 354$ ) with 12 **molodot** (the plural of molod):

$$12 \text{ molodot} = 354 \text{ days, } 8 \text{ hours, } 876 \text{ halakim;}$$

thus 12 molodot are slightly longer than 354 days. Similarly, an **embolismic** year has 384 days ( $354 + 30 = 384$ ), whereas

13 molodot = 383 days, 21 hours, 589 halakim

is slight shorter. Nonetheless, the Metonic cycle of intercalation gave a year whose average length was

$$1 \text{ yr} \cdot \frac{235 \text{ molodot}}{19 \text{ yrs}} \cdot \frac{29.53059 \text{ days}}{1 \text{ molod}} = 365.24682 \text{ days}$$

an approximation of the tropical year of 365.24219 days to an accuracy less than one day in 216 years!

Back in the 2nd c. CE, Rabbi Yose ben Halafta used the Hebrew Scriptures to develop a chronology of the world, in which he dated the day of Creation (as told in Genesis). This he placed as having begun at 6:00pm on Saturday, October 5, 3761BCE! More specifically, he computed that the very first new Moon started at 5 hours, 204 halakim after sunset two days later. Later, in the 12th c., Rabbi Moses ben Maimon, popularly known as Maimonides, suggested using this dating to reset the beginning of the Jewish era. Since then, the Jewish calendar has counted years from this date with the designation AM, for *anno mundi* [L. in the year of the world]. Thus, the current Jewish year, running from September 30, 2008 to September 18, 2009 is AM 5769.

The Jewish calendar includes *four* “new year” celebrations (!), but only two of them are of great importance. Apparently, the two ancient Hebrew kingdoms of Israel and Judah had followed different calendars – Israel the ecclesiastical calendar and Judah the civil calendar – so both new year celebrations were retained thereafter.

The ecclesiastical new year occurs at the new Moon after the spring equinox, according to the Biblical prescription found in Ex 12:2:

“This month [Nisan] is for you the first of months.”

At the full Moon of this month, on Nisan 14, the important feast of **Pesach** [Heb., Passover] is celebrated.

The civil new year is celebrated on the first two days of Tishrei, officially the first month of the Jewish year, with the feast of **Rosh Hoshannah** [Heb., Head of the Year]. The practice of celebrating the feast across two days derived from the difficulty of Jews in the Diaspora to determine with certainty the time of this new Moon.

The month of Tishrei is also the month of **Yom Kippur** [Heb., Day of Atonement] (Tishrei 10), the “Sabbath of Sabbaths”, and holiest day of the Jewish year. Also in Tishrei is **Sukkot** [Heb., Booths] (Tishrei 14), a seven-day festival whose final day is **Hoshannah Rabbah** [Heb., Great Supplication] (Tishrei 21), a day which includes special prayers to God for rain in the coming year.

Because Jews are forbidden by religious law from all work – including food preparation and burial of the dead – on the Sabbath (every Saturday), it was important to design the calendar so that this kind of work is not prohibited on two consecutive days. So Yom Kippur can never fall on a Friday or a Sunday. Also, since the prayers for rain are considered a violation of the rules for rest on the Sabbath, Hoshannah Rabbah cannot occur on a Saturday. To ensure that these restrictions are met, there are special **postponement** rules followed for the intercalation or extracalation of a day from the year.

Consequently, there are six kinds of year in the Jewish calendar, depending on whether it is a **common** year (12 months) or **embolismic** year (13 months), and whether it is **deficient** (one day extracalated), **regular** (no change), or **abundant** (one day intercalated).

The Metonic cycle determines whether the year is to be common or embolismic, but a number of factors decide whether the year is deficient, regular or abundant.

In a common regular year, the 354-day year's structure is as in the table on p. 12 above. In a deficient year, Kislev 30 is omitted and this 3rd month of the year has only 29 days; in an abundant year, the 2nd month Cheshvan is extended from 29 to 30 days. In embolismic years, the same pattern sets up, but the 6th month, Adar, with 29 days, is replaced with two months, Adar I, with 30 days, and Adar II with 29. So embolismic years are just 30 days longer than common years. The lengths of the years are then as in this table:

	deficient	regular	abundant
common	353	354	355
embolismic	383	384	385

The time of the molod of Tishrei for the coming year is computed by using the year number to determine how many months have elapsed since the beginning of time; then one can find the exact moment of this molod and therefore the appointed number of days in the current year.

Since the next molod of Tishrei should occur on the first day of that month, one may have to adjust the length of the current year to ensure this. (Recall that 12 molodot are slightly longer than 354 days, and 13 molodot are slightly shorter than 384 days.) This temporarily establishes whether the current year will be deficient, regular or abundant. Then, the postponement rules come into play to ensure that the holy days in Tishrei do not fall on a day adjacent to a Sabbath. They work as follows:

1. It has been determined that the moment of the astronomical new Moon (the Moon's conjunction) in Jerusalem precedes the visibility of the first crescent by 6 hours. So, if the conjunction that determines the molod of Tishrei were to take place after noon on a given day (6 hours before the start of the next day), the Moon's crescent would not be visible *on the same day*. To ensure that the first day of the year coincides with the sighting of the Moon, this rule stipulates that when the molod begins after noon, Rosh Hashannah (Tishrei 1) of that year should be postponed, i.e., the previous year should be extended by a single day.

2. If the molod of Tishrei falls on a Sunday, Wednesday or Friday, Tishrei 1 must be postponed a day (and possibly a second day, if the first rule had already gone into play), otherwise (a) in the case of a Wednesday or Friday, Yom Kippur (Tishrei 10) would be immediately followed by or precede a Sabbath; and (b) in the case of a Sunday, Hoshannah Rabbah (Tishrei 21) would fall on a Saturday. Consequently, Rosh Hashannah can only fall on a Monday, Tuesday, Thursday or Saturday.
  
3. If in a common year, the molod of Tishrei falls on a Tuesday at 9 hours, 204 halakim after 6:00pm or later, then this year is regular (as the molod of Tishrei of the next year would fall on a Saturday after noon). But this requires, by the first rule above, that the year be extended one day, and by the second rule (as the next Tishrei 1 cannot be on a Sunday), that it be extended yet a second day. As a result, the current year would last more than 355 days long. To avoid this circumstance, we delay *the current year* by one day, making it abundant; however, this forces Tishrei 1 to fall on a Wednesday, which is forbidden, so we delay it a second day, to Thursday, making it a regular year once more! The following Rosh Hashannah then falls on a Monday.

4. If, in a year after an embolismic year, the molod of Tishrei falls on a Monday at 15 hours, 589 halakim after 6:00pm or later, then the embolismic year must have had a molod of Tishrei that fell on a Tuesday after noon, making it a regular year. But the first rule above would then trigger, causing a one-day postponement to Wednesday, whence the second rule would come into play, causing a second postponement to Thursday, and the embolismic year would then be only 382 days long. To avoid this, we postpone Tishrei 1 of the year after the embolismic year from Monday to Tuesday. The embolismic year now has 383 days, and no further changes are required for the following year.

It may appear that, since Rosh Hashannah can fall on any of four days of the week and since the year can have one of six different lengths, there are 24 ( $4 \times 6$ ) different possible calendar arrangements. In fact, there are only 14 since some of the combinations are impossible to arrange. (This is the same as the number of combinations of our current calendar, as it can begin on any of 7 days of the week and be either a common year or a leap year.)